ELECTRICAL ENGINEERING

JANUARY 1961
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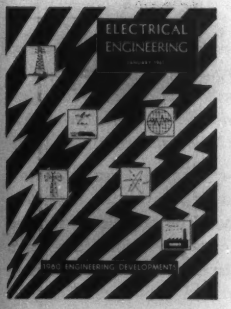

THE COVER: The dynamic expansion of electrical engineering, represented by the six AIEE Divisions — Communication, General Applications, Industry, Instrumentation, Power, and Science and Electronics, is depicted on this month's cover, which was designed by Bill Pause.

Contents

Engineering Progress—1960 1

A review of important developments in the field of electrical engineering during the past year by 38 AIEE Technical Committees

Engineering Developments—1960 2

Pictorial report showing some of the many outstanding electrical engineering achievements during the past year

The Beginning of Electrical Engineering *Harold Sharlin* 54

Electrical engineering as a science sprouted directly from the technical problems of the telegraph industry during the second half of the 19th Century

Standardization of Electronic Test Equipment *D. B. Dobson, L. L. Wolff* 60

An investigation into the practicability of effectively standardizing ordnance missile-system test equipment

Performance of Electrical Connectors at High Altitude *A. L. Coats* 67

Operation of electrical connectors at altitudes in the range of 100,000 to 200,000 feet presents special breakdown problems

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Published monthly by American Institute of Electrical Engineers

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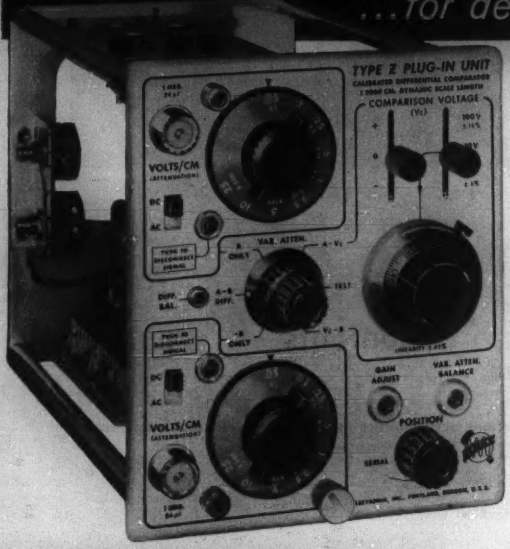
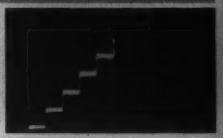
500-TIMES MAGNIFICATION–VERTICALLY

...for detailed waveform analysis

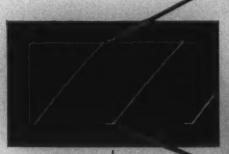


Waveform Details of a 100-v Staircase

Vertical Expansion
500 Times
Horizontal Expansion
500 Times



Vertical	Horizontal
50 mv/cm	10 μsec/cm
$V_C = +92.5$	



Vertical	Horizontal
25 v/cm	5 ms/cm
$V_C = 0$	

Vertical	Horizontal
50 mv/cm	10 μsec/cm
$V_C = -5.5$	

TYPICAL APPLICATIONS

FAST-RECOVERY AMPLIFIER—observe small signals riding with large gates.

MODULATION MONITOR—measure amplitude modulation on a digital train pulse.

HIGH-AMPLITUDE HUM REJECTION—reject up to 200 volts peak-to-peak common-mode hum.

SEMICONDUCTOR CHARACTERISTICS—measure Zener diode ac impedance and Zener voltage together, measure transistor output impedance.

PULSE-HEIGHT ANALYSIS—select any pulse above a preset dc level.

COMPONENT MATCHING—check components to easily-interpreted tolerances.

MAIN CHARACTERISTICS

3 Modes of Operation—as a conventional preamplifier, as a differential-input preamplifier, or as a calibrated differential comparator.

50-mv/cm Sensitivity—nine calibrated attenuation steps to 25 v/cm.

Wide Passband—dc to 13 mc with Tektronix fast-rise scopes.

±100-volt Dynamic Range—permits common-mode signals up to 100 volts to be applied to the unit without attenuation.

40,000 to 1 Common-mode Rejection Ratio—allows measurement of differential signals less than 50 millivolts.

Comparison Voltage Accuracy—within 0.25% on the ±1-volt scale; within 0.20% on the ±10-volt scale; within 0.15% on the ±100-volt scale.

Safety Feature—the Type Z eliminates "floating oscilloscope" operation.

AC and DC VTVM—extends oscilloscope accuracy in both ac and dc voltage measurements to 0.2%.

Price, Type Z Plug-in Unit, f.o.b. factory **$525**

New differential plug-in preamplifier rejects up to 100 v of an input signal . . . accepts 100-v waveforms for oscilloscope display at 50-mv/cm sensitivity . . . provides an equivalent vertical scale length of ±2000 centimeters.

You can now display small segments of large waveforms at maximum oscilloscope sensitivity, with vertical expansion equivalent to as much as 500 times. You can select magnified "window" displays of all portions of a waveform, and make amplitude measurements with a degree of accuracy that closely approaches the possibilities of digital techniques. The flexibility and simplicity of the analog (oscilloscope) presentation is retained for accurate analyses of complex waveforms.

The new Type Z Plug-In Unit is a triple-purpose device, acting also as a conventional preamplifier and a differential-input preamplifier. It can be used in all Tektronix Type 530, 540, 550, and *580 Series Oscilloscopes. Ask your Tektronix Field Engineer to demonstrate the dynamic range, waveform resolution, and amplitude accuracy of the Type Z in your application.

**with Type 81 Adapter.*

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drawout motor controller
. . . 2000 to 5000 v

so low..

New *SpaceMaker* control is the first completely new high-voltage motor controller in more than a decade. It is the first two-high, 2 to 5 kv control center design — so compact that two complete controllers require no more floor space or head room than one conventional unit. It is also the first controller in its voltage class to feature complete drawout construction for unprecedented safety and accessibility.

Downtime for inspection and maintenance is reduced to an absolute minimum. The contactor carriage is quickly racked in and out of connect position by means of a ratchet door handle. One man can easily roll the carriage out of the control enclosure. No flexible leads or bolted connections are involved. Arc chutes and barriers simply lift out, and pole pieces rotate to completely expose the entire contact structure. Other inspection and maintenance procedures are equally simplified.

And, all inspection and maintenance are accomplished in complete safety without the need for de-energizing the bus. It is impossible to come in contact with "live" parts. Racking of the carriage is done with the metal door in closed position. Insulated shutters automatically isolate live line connections when the contactor is racked out.

Vol. 8(
1961

A new addition to the famous three star line

New! Save space and money with Cutler-Hammer's Size 00 A-C Magnetic Starter

Takes up to 20% less space... costs 18% less than Size 0 Starters. Now you get two big new bonuses in control selection . . . less space and less money Both with the all new Size 00 Starter.

Before, you had to use a larger starter in applications where it really wasn't needed. But, now you can use the Size 00 in about 40% of the applications where the Size 0 is usually used.

The new Cutler-Hammer Size 00 Starter performs to the same high standards you get from all Cutler-Hammer Starters. And, you still get vertical, dust-free contacts which add so much to more reliable starter performance. Your choice too, of 2-coil or 3-coil overload protection in the same small enclosure.

The Bulletin 9586 Size 00 Starter can be used on any general application. Its maximum horsepower ratings: Three phase: 208/220 volts, 1½ hp. 440/550 volts, 2 hp. Single phase: 115 volts, ⅓ hp. 230 volts, 1 hp. It's available open or in NEMA 1 enclosure. Send for Pub. LO-40-A228.

Why you get more from Cutler-Hammer. New things are happening at Cutler-Hammer—new, better products, new engineering ideas and talent, new plant capacity. We're on the move. And, we'd like to show you how we could help you in any electrical control problem. Contact the nearest Cutler-Hammer distributor.

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Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A

New and Improved Products . . .

Solid-State Pyrometer . . .

This new line of heavy-duty millivolt pyrometer controllers containing solid-state control units features a galvanometer sensing element, a high-

resistance input circuit, spring-backed jewel bearings for shock resistance, minimum full scale span of 10 millivolts, ±0.5% accuracy against scale, and ±1% accuracy within an ambient range of 50 to 120 F. The control relay is actuated by a signal from a photocell mounted on the set point index. A vane on the mechanism pointer cuts the light to the photocell when the measured variable reaches the set point. *Daystrom, Inc., Weston Instruments Div., 614 Frelinghuysen Ave., Newark 12, N.J.*

IBM 1401 Additions . . .

Three additional pieces of compatible peripheral equipment will greatly expand the capabilities of the *1401* solid-state business data processor. These are the *1405* random access storage disk units that will store, search, and extract one letter or number from among 20 million at a speed of ½ second; a *1407* console inquiry station that will enable the operator to check on the status of data in the *1401*; and a paper tape reader for reading 4 to 8 channels of information at 500 characters per second. *International Business Machines Corp., 112 East Post Rd., White Plains, N.Y.*

Rapid-Access Catalog System . . .

This fast information search and read-off system employs a closed loop of 16mm microfilm that can locate an item and present it visually in a matter of seconds. The system was designed for operations requiring on-the-spot look-up, such as price confirmations, insurance policy reporting, and spare parts recording. A single line of information in a catalog of 400 pages containing 25,000 items arranged alphabetically can be located and read off in 1.5 seconds. The data which has been recorded on the film loop is driven at a speed of 40 inches per second, with a stop-start capability of 1/200 second. An alphabetic binary code keyed to each item locates the proper frame containing the data. *Ferranti Electric Inc., 30 Rockefeller Plaza, New York 20, N.Y.*

Miniature Silicon Rectifiers . . .

Two new high-voltage silicon plug-in rectifiers equipped with tube bases permit direct replacement of types *6X4, 12X4, OZ4,* and *6X5* vacuum tubes. Rated at 1,250-volts peak reverse voltage at 80-ma d-c output, the *ST-8* rectifier is designed to provide better surge current capabilities, fewer noise characteristics, and high-temperature operation on vibrator-type power supply applications. The miniature *IN570,* rated at 1,500 PRV at 75-ma d-c output, is designed to replace MIL

types *6X4* and *12X4* vacuum tubes in wide range of power supply applications, including radio and television, test equipment, computers, and related data-processing equipment. *International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.*

Wireless Microphone . . .

This lavalier-type wireless microphone appears to have overcome many of the problems such as excessive weight, bulkiness, low audio fidelity, interference, and dead spots in the radiation pattern that have plagued other self-contained microphones. Despite its low power output of .020 watt, the Vega-Mike operating in the 25- to 45-mc range has a useful range of ½ mile. *Vega Electronics Corp., 10781 N. Hwy. 9, Cupertino, Calif.*

Wide Range Magnetron . . .

The *X-747* shown here with its magnet and cavity can be electronically tuned over the 400 to 1,200-mc range with a nominal output power of

100 milliwatts. Easier to use than other magnetrons of this type, the *X-747* requires no complicated regulation of heater voltage. Back heating is eliminated through indirectly-heated matrix cathode, and by using the advanced electron injection design. Extremely linear tuning characteristics also greatly simplify circuit design. *Eitel-McCullogh, Inc., San Carlos, Calif.*

Fleapower Motor . . .

When smaller motors and timing devices are made this company will probably make them. The latest development in microminiature is a 115-volt 400-cps single-phase hysteresis-type motor that measures 3/8 inch in diameter, 9/32 inch in length and consumes less than ½ watt of power. Developed to power a miniaturized, hermetically sealed repeat cycle timer, the motor is also used to power the smallest practical digital elapsed 4-digit timer indicator. *A. W. Haydon Co., Waterbury, Conn.*

High-Speed Fault Protection . . .

Availability of a new low-voltage current-limiting circuit breaker that provides economical high-speed protection against fault currents up to 200,000 amperes has been announced by this company. Designed for industrial plants and commercial buildings, the K-Don breakers integrate in a single compartment the protection of Amp-trap current-limiting fuses with the protective features of their K-line stored-energy breakers, along with a unique device that prevents single phasing. *I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia, Pa.*

(Continued on page 14A)

International Rectifier's new High Voltage Columns feature twice the power for equivalent space and far greater reliability than any similar solid-state or tube-type device.

• 1 KW PER CUBIC INCH • EFFECTIVE HEAT DISSIPATION • DIMENSIONAL FLEXIBILITY • NEW DESIGN SOPHISTICATION

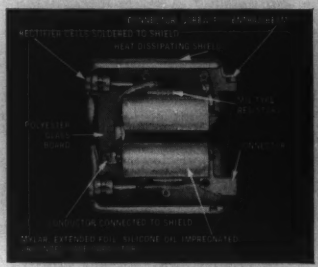
Here's a new concept of superpower tube power supply with truly significant design advancements. These modular rectifier columns are rigidly homogenous, cooled, and shielded. Relative positions of all component parts are equal. Internal voltage division by a ladder principle, using capacitors and resistors, established firm potential levels for all electrical and mechanical parts at all frequencies. Each cell within the column is protected from external electric fields, and is effectively cooled, by individual, well rounded corona shielding. Column design allows free air circulation for effective heat removal in any mounting position. Because of the rounded, smooth exterior of the column and subsequent low air speed requirement, air pressure drop is reduced. In many cases, forced air cooling or the use of liquid or gaseous coolants is not required.

The length of the modular column may be controlled by varying the length of its strong, plastic, central beam—according to the number of individual cells required. The ends of the resulting string are always shielded by separate terminal pieces. This dimensional flexibility is accomplished without sacrificing reliable performance or delivery time.

Standard Columns are rated to 120,000 Volts—3 Amp and 68,000 Volts—50 Amp. For higher voltage, columns can be cascaded or used in series.

The advantages these Columns offer to designers of radar, television and broadcast transmitters; particle accelerators; induction heaters; pulse modulators; etc., are significant. Now, by eliminating filament power supply, equipment can be designed smaller and at lower cost. Now, higher power and predictable reliability in the smallest possible space can be attained. Now, development time can be shortened and procurement cycles simplified by specifying these revolutionary new Modular Rectifier Columns.

Write today for our special 16-page Design Engineering Manual which describes and illustrates these important new devices in full detail.



All sub-assemblies of each module are exactly equal in main parameters...in capacitance between each group of devices and ground ...in inductance in series with each group of devices and within each device...in inductive coupling between adjacent connectors of different groups of devices...and in capacitive coupling from one group of devices to another.

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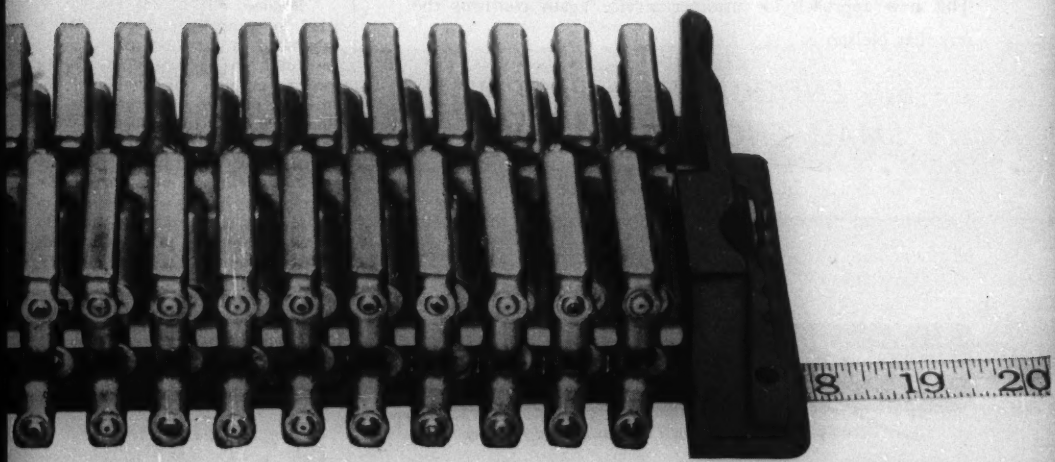
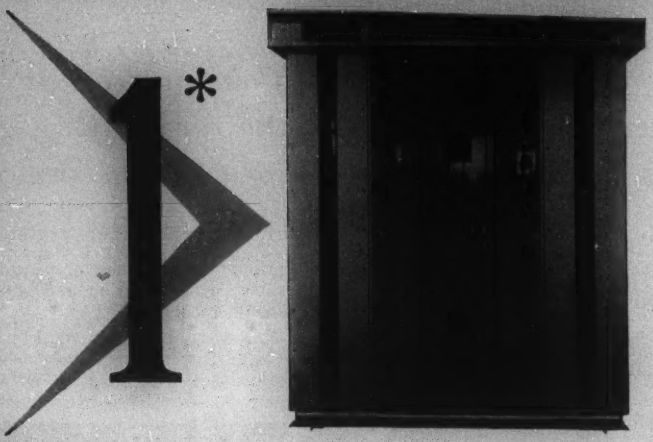




*1 — that's right, *just one.* It's the only one of its kind because it was tailor made by Nelson for a major utility company for a specific purpose. It is, however, a good example of Nelson's "Controlled Power Package" which includes motor control centers, low voltage switchgear, high voltage starters, supervisory and special control, and other equipment in a single weatherproof structure, all interwired, ready to hook up to line and load.

This approach means important savings because Nelson takes on the detailed engineering required for coordination and interconnection, and also eliminates the necessity of engineering a separate building. You spend your money where it counts—on the electrical equipment.

This new approach to customer service again confirms the fact that Nelson is

BIG ENOUGH TO PERFORM
SMALL ENOUGH TO CARE

Be sure to let your Nelson representative figure your next job. You will find him listed in the Yellow Pages of major city telephone directories.

NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

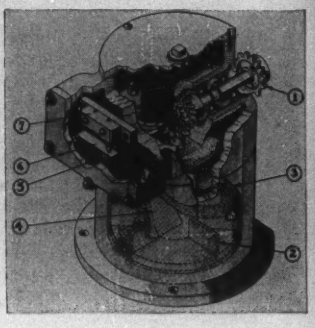
P. O. BOX 5385 NATIONAL 7-5530

New & Improved Products

(Continued from page 8A)

Safety Switch . . .

Machines, equipment, and processes are protected against damage resulting from stoppages with this novel motion safety switch. A sprocket (1) provides the linkage by chain with the equipment to be protected. Through a set of bevel gears a paddle wheel



(2) is set in motion in a body of oil (3) which tilts a vane (4) to which is attached a horizontal shaft (5) that is half-round to provide a flat surface for a hinged leaf (6) when the system is idle. Once the paddle and oil are in motion, however, the leaf is titled by the half-round portion, thereby actuating a microswitch (7) to open or close the circuit as desired. *Fuller Co., Catasauqua, Pa.*

Digital Extensometer . . .

Because surface hardness is related to elongation when a strip is cold-rolled in a reduction or temper pass mill, this relationship may be used to evaluate the quality of the finished product. Measurement of elongation is accomplished by two heavy-duty magnetic pulse generators geared to the contact rolls at the entry and exit side of the mill. These transmit electrical impulses proportional to the rotating speed of both rolls. On the assumption that peripheral speeds of the entry and exit rolls are identical with strip speed, one can compute tension by counting the number of pulses produced by the exit roll during the time required to accumulate a predetermined number of pulses produced by the entry roll. *Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.*

(Continued on page 18A)

West bay of the 130,000-sq-ft transformer assembly and test building showing transformers in various stages of manufacture. At right is the vacuum drying tank, one of the largest in the industry. Vacuum as low as 10 mm of mercury can be obtained . . . for efficient drying of transformers.

The industry's finest facilities for designing, building and testing power transformers are housed in the Allis-Chalmers Terre Haute Works. This investment features over 740,000 square feet of floor space. All product design and test developments are closely coordinated with five major Allis-Chalmers plants at West Allis, Wis., Pittsburgh and York, Pa., Gadsden, Ala., and Boston, Mass. These plants produce a complete range of generation, transmission and distribution equipment for industries and utilities.

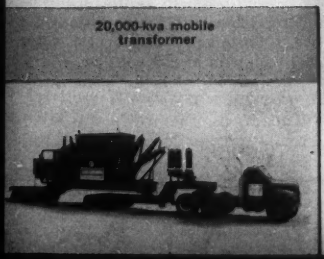
The Terre Haute Works is typical of Allis-Chalmers look-ahead philosophy that has pioneered so many industry "firsts" in all phases of electrical generation, transmission and distribution. Also an integral part of this plant are the advanced facilities for building and testing oil circuit breakers and switchgear. *Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.*

ALLIS-CHALMERS

Pacing Power Progress

Shipment of Allis-Chalmers power transformers on railway spur line flatcars indicates the varied size and application range of these Terre Haute products.

A-1390



Electromechanical Components and Systems Capability

AIRESEARCH MOTORS OPERATIONAL -425° TO +600°F

Specialized aircraft motors developed by AiResearch operate at temperatures from −425° to +600° F. ambient. The range of this compact, lightweight, ½ H.P. motor is −65° to +600° F.

AiResearch diversification and experience provide full capability in the development and production of electromechanical equipment and avionic controls for aircraft, ground handling, ordnance and missile systems.

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Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Manufacturing Division

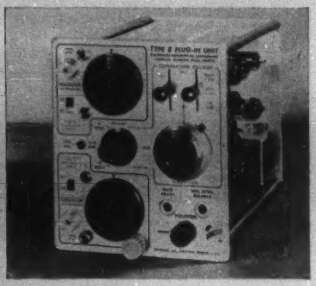
Los Angeles 45, California

New & Improved Products

(Continued from page 14A)

Plug-In Unit . . .

Type *Z* is a unique differential amplifier with a large dynamic range that fits all Tektronix oscilloscopes accepting the "letter-series" plug-in units. The device enables measurements of small segments of large waveforms at



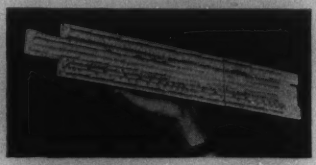
maximum vertical sensitivity, as well as vertical expansion of a waveform for extremely detailed analysis and measurement. A 100-volt signal may be observed with 0.05 volt per centimeter resolution, providing up to 500 times vertical magnification. *Tektronix, Inc., P. O. Box 500, Beaverton, Ore.*

Digital Voltmeter . . .

This portable, multi-range d-c voltmeter designated *BH190* contains an analog-to-digital conversion system composed of a tape-slidewire potentiometer 144 inches long calibrated and geared to an in-line counter for readout accuracy to 0.1%. Calibration is better than 0.05% and resolution better than 0.02%. Full-scale travel of the servo-driven slidewire is accomplished in 8 seconds. *Howell Instruments, Inc., 3479 West Vickery Blvd., Fort Worth 7, Texas.*

Radiation Slide Rule . . .

A major reduction in the number of steps formerly required to obtain information relating to the radiation from a black body can be made with this new slide rule. Direct reading of values in both watts and photons per



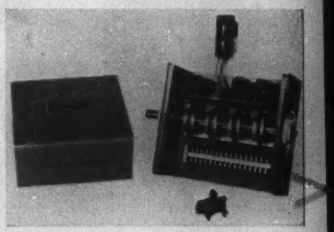
square centimeter can be determined. Twin temperature scales provide readings in degrees centigrade or degrees absolute over a range of −180 C to 10,000 C. Quantities such as the radiant flux density in a given wavelength, or the corresponding quantities expressed in photon units may be readily obtained for a black body over a range $\lambda T = 2 \times 10^2$ to $\lambda T = 4 \times 10^6$ micron degrees with an accuracy of about 1%. *Walsh Engineering Sales Co., 718 E. Manchester, Inglewood 3, Calif.*

X-Band Power . . .

The highest cw power yet offered in the X-band is now available in the *VA* 849 series amplifier klystrons. The new tubes, rated at 20 kw, cover a frequency range of 7.125 to 8.5 kmc. Tunable over a 60-mc range, these 4-cavity tubes have been tested to more than 25 kw. Gain is 37 db and the bandwidth is a minimum of 30 mc. The synchronously tuned power gain and bandwidth are 53 db and 15 mc, respectively. Focused electromagnetically, the tubes are self-centering in the focusing electromagnet with no critical adjustments necessary. *Varian Associates, 611 Hansen Way, Palo Alto, Calif.*

Rotation Cam Limit Switch . . .

This switch is primarily applicable to furnaces, ovens, curing operations, or material handling mechanisms where motion is expressed in shaft rotation. Featuring plug-in snap switch receptacles that are permanently wired



to screw-type terminals, the switch allows circuits to be disconnected to facilitate maintenance and eliminate down time. By loosening a screw and rotating the cams relative to each other, one may obtain a continuous range of open and closed circuit from 360 degrees down to approximately 8 degrees. These SPDT switch contacts have a 15-ampere rating at 115 volts a-c, 10 amperes at 220 volts a-c, and 5 amperes at 440 volts a-c. *Gemco Electric Co., 25685 West Eight Mile, Detroit 40, Mich.*

(Continued on page 36A)

ENGINEERING PROGRESS—1960

Reviewed by AIEE Technical Committees

YEAR-END reports from 38 technical committees record many noteworthy developments in the six broad fields of activity covered: communication, general applications, industry, instrumentation, power, and science and electronics.

In communication, broadcasting facilities continued to expand with 3,500 AM standard broadcast stations, 800 FM, and 590 television stations in operation at the year's end. The Bell System initiated for public use its experimental electronic switching system at Morris, Ill. Outstanding progress in data communications was made in the utilization of voice-grade facilities. Longer range tropospheric scatter and space satellite systems highlighted developments in radio communication systems. Space communication took giant strides, proving out advanced communication techniques with the Pioneer V satellite and Project Echo.

In the area of general applications, significant developments in aero-space transportation were reported in space systems, thermionic converters, cryogenics, and environmental problems. There was a strong movement during the past year toward engineering domestic appliances in depth, based on new research of human needs. In railroad and transit industries, electric propulsion equipment received new impetus. And in all areas, the importance of higher lighting levels has gained wide recognition.

Notable among many developments in industry were the emphasis on fuel cells in the chemical field and the world-wide acceptance of the silicon rectifier in the electrochemical industry as the principal conversion means in low-voltage and many high-voltage applications. Feedback control continued to expand its influence and now includes management functions with the application of feedback control techniques to organizational systems. The metal industry began the application of digital forms of transistorized automatic controls to achieve high production of quality products. In the petroleum industry, large strides were made in the protection of motors and the expanded use of automatic control equipment.

Progress in instrumentation was made in television systems for control, supervision, and return of information in the case of a soft landing of a vehicle on the moon. Several designs of magnetic support bearing systems for integrating watt-hour meters were announced in 1960. The past year has also seen a substantial growth in industrial telemetering in connection with supervisory control of pipeline pumping stations in the petroleum industry.

In the power field, the Extra-High-Voltage (ehv) Field Testing Project at Cornell University moved ahead with the completion of the construction phase contract. In power generation, there has been steady progress in the development of atomic power plants and a renewed interest in hydroelectric developments. The use of static components in protective relays is increasing; during 1960, the all-static, overcurrent relays were placed on the market. Watercooling of the copper conductors in the stator windings of turbine generators was employed for the first time in two large conductor-cooled machines built by General Electric and a newly developed diesel-engine generator unit supplying power to a motor-driven refrigeration compressor is contributing to the replacement of iced refrigeration railroad cars.

View of the massive antennas of the AN/FRC-47 tropospheric scatter communication system developed by General Electric for the U. S. Air Force.

Developments in science and electronics are notable. The year 1960 saw the first commercial installations of standard line transistor computers and the successful blending of electronic computer systems with character recognition equipment. Significant advances were made in the state of the art of devices to convert solar, nuclear, and chemical energy directly to electric energy. Improved semiconductor materials have led to thermoelectric devices capable of 12% conversion. The alternating gradient synchrotron of the Brookhaven National Laboratory has produced a beam of protons at an energy of more than 30 billion electron volts (bev), giving United States scientists the world's highest energy machine for study and research on nuclear structures.

Communication

BROADCASTING

BROADCASTING continued to grow during 1960. Stations on the air numbered approximately 3,500 AM standard broadcast, 800 FM, and 590 television operations. Educational television stations among the last

(*Continued on page 32*)

1960 ENGINEERING DEVELOPMENTS

Vol. 80
1961

A Photographic Record of Some of the Important Electrical Engineering Achievements of the Year

▲ Aerial view of Brookhaven National Laboratory's Alternating Gradient Synchrotron (AGS). At lower left edge of huge magnet ring is the linac (linear accelerator) building, housing injection system. Large square structure is target building, where experimental equipment for high-energy physics research is installed.

◄ Cockcroft-Walton generator in AGS linac building provides initial acceleration of 750,000 ev to protons, upon which they are injected into a 50-mev linac before entering AGS orbit.

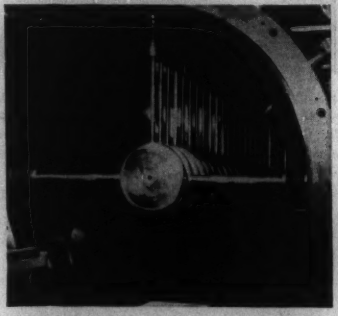
► Over-all view of linac and auxiliary equipment. To right of 110-foot tank and toward rear are four high-power r-f system "towers."

▲ One of the 240 magnet sections for use in the Brookhaven National Laboratory's Alternating Gradient Synchrotron, shown with the coils in place. The vacuum chamber, in which the accelerated protons are guided is to be centered in the gap between the magnet poles. Each of the magnet sections is made up of about 3,200 laminations of 0.035-inch steel plates, and weighs approximately 16 tons.

▲ View in AGS tunnel, looking downstream, with one of the 12 r-f accelerating stations in foreground. Small cubicle to left contains control and auxiliary circuits. First large cubicle in center is r-f power amplifier, which provides drive for r-f accelerating cavity. Next large cubicle is saturating supply, which tunes cavity.

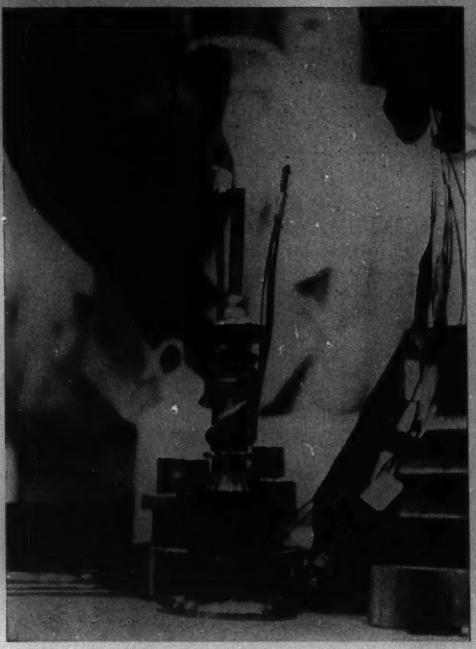
◄ Motor–generator set of main magnet power supply. A 47-ton flywheel stores energy from the 6,000-hp motor between pulses.

► Internal arrangement of low-energy end of tank. Drift tubes and their support stems are seen inside tank. Spherical object in upper-right-hand section of tank is a ball tuner, which serves to provide the correct resonant frequency of the tank.



► Inside tunnel of AGS at conjunction of linac and main magnet enclosure. The 50-mev proton beam leaves linac and travels along 4-inch pipe to lower right, passing through focusing lenses and steering magnets into orbit of magnet ring. Pipe extending across aisle to left is exit pipe from analyzer magnet which bends beam through 25 degrees to permit determination of energy spread of protons. Above head of man in foreground are steering magnets for horizontal and vertical deflections. In foreground is viewing box in which are located adjustable slits, for aligning beam and examining its spatial and angular distribution so correct focusing adjustments can be made. Also inside viewing box is quartz plate which can be rotated into beam for visual observation of beam position and dimensions. Protons impinging on quartz produce light, observed by television camera.

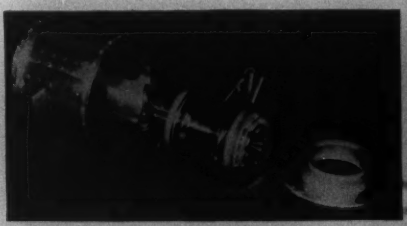
▲ One of two 2,500-watt thermoelectric "subgenerators" is shown under test at Westinghouse new products laboratories. Developed for U. S. Navy, 5,000-watt generator is an experimental unit for materials evaluation. It is built up from thermoelectric assemblies, or modules, which can be arranged electrically to give outputs from 10 volts at 500 amperes to 120 volts at about 42 amperes.



▲ Scientist at General Atomic Division of General Dynamics Corporation prepares cesium cell converter unit for reactor tests in which 90 watts of electric power were produced directly from the heat of nuclear fission. The cesium cell contained a nuclear fuel element made of uranium carbide and zirconium carbide. The fuel element, or thermionic emitter, is only about ½ inch long.

Courtesy General Electric Company

► Duo-plasmatron ion engine, designed by J. M. Ferguson of Wright Air Development Division Propulsion Laboratory, ionizes propellant atoms by electrical bombardment and derives its thrust by expelling the ionized atoms electrostatically.



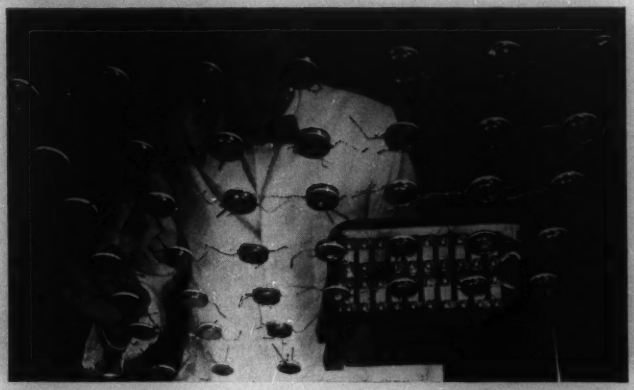
◄ MHD power generation is process of extracting electric power directly from ionized gas as it moves through a magnetic field. Gas flows up through steel casing to generator; electrodes connected to each side of casing, between the magnetic poles, drain off the current.

► Elements of new type thermionic converter tube are examined by Dr. K. G. Hernqvist of RCA Laboratories. Unlike previous types requiring temperatures of over 2,000 C for effective operation, it functions within ranges of temperatures produced by burning ordinary fuels, as well as solar heat in space.

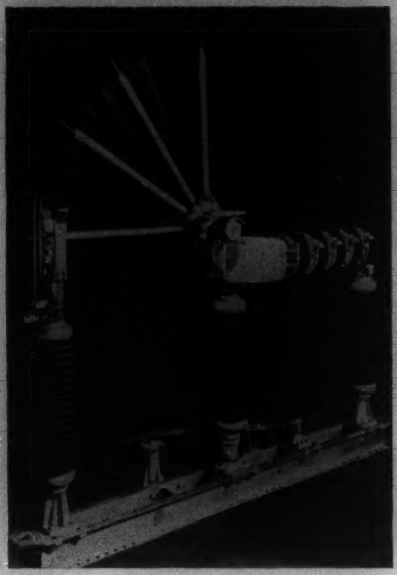
▲ General Electric Company's model *AE-12* fuel cell power pack developed for the U.S. Marine Corps and Army Signal Corps weighs 35 pounds and can easily be handled by one man. As a power source for field radar, the operating unit (shown here in mock-up) will produce 200 watts of direct current at 24 volts. Replaceable canisters inside perforated guard at top produce fuel for 14 hours of unattended operation. Corner of casing is cut away to show arrangement of individual fuel cells within power pack.

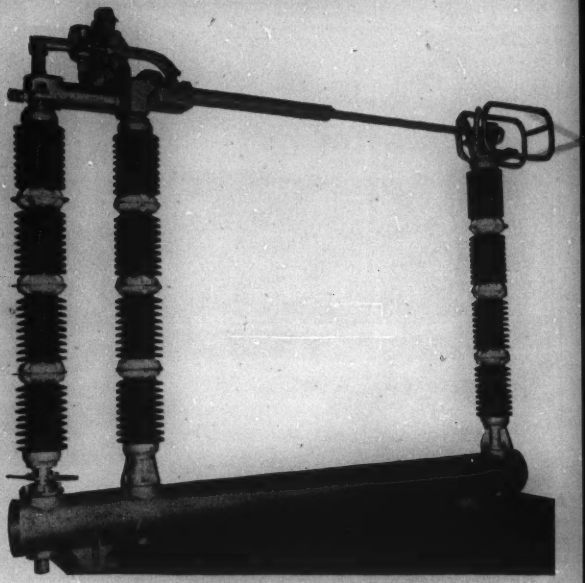
▲ Dr. W. E. Shoupp, technical director of Westinghouse atomic power department, holds combination thermoelectric–thermionic test device designed to extract electric power directly from fuel elements in a nuclear reactor. To use heat energy of higher temperatures, a nuclear fuel element was built with thermionic generator in its center and thermoelectric generator surrounding it. The former operates at about 3,500 F, but will not function efficiently at temperatures below 2,700 F. A thermionic unit, however, does not operate at such high temperatures, but works well at 600 to 1,800 F. By putting the two types of generators in tandem, heat passing through the thermionic generator flows through the thermoelectric unit. Elements are wired in series to give a combined electrical output over a very wide temperature range.

◄ Westinghouse magnetohydrodynamic (MHD) generator produces electric power continuously from the combustion of a conventional fuel—furnace oil. In MHD generator shown here, superhot, electrically conducting gas—a plasma—is passed between poles of a powerful magnet. This ionized gas passes through a ceramic-lined tube at 1,800 miles an hour, cuts across the magnetic field of the magnets, and produces electric power. Operating at about half its full power rating, the new generator has produced 5 kw and has run continuously for 4 minutes, as opposed to about 5 seconds for previously reported MHD generators.

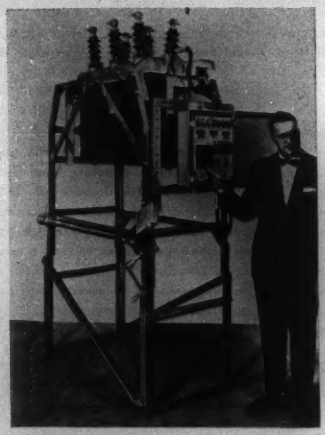


► All or portions of 41 thermionic converters from the General Electric Company's Missile and Space Vehicle Department, Philadelphia, Pa. These converters utilize the sun's energy to equal the power output of one thousand 15-ampere-hour batteries for 1 year.



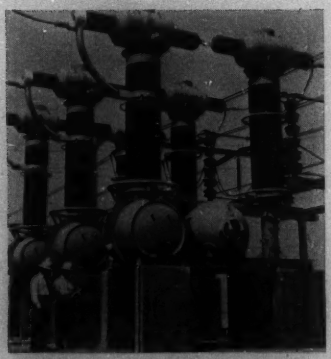


▲ This 345-kv 1,600-ampere outdoor disconnect switch is the "heavyweight" of a line of Westinghouse switches with voltage ratings of 7.2 to 196 kv and standard current ratings of 600, 1,200, and 2,000 amperes. The switches can be converted to a load break switch in the field by adding an interrupter unit and auxiliary blade.

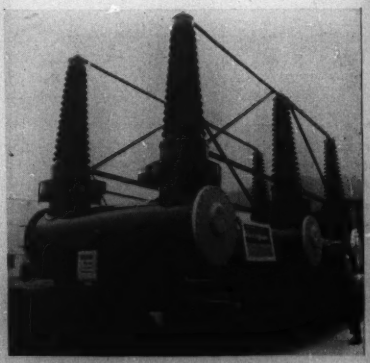


(*Upper left*) Circuit-Switcher, resembling a load-interrupter switch in appearance but working more like a circuit breaker, is the generic name for the S&C Electric Company's new family of 34.5- to 138-kv switchgear, which can handle a number of circuit-interrupting duties. Heart of the device is an interrupting unit capable of carrying current continuously and withstanding short-time surges, combined with a "brain" mechanism that gives built-in sequence control. Thus, it differs from a load interrupter switch, where the disconnect is dominant and the interrupting unit is an accessory.

◄ Operation of Line Material Industries' new electronic control for oil circuit reclosers is explained by Blaine Schultz, manager switchgear engineering. The type *RE* and *WE* reclosers embody all the advantages of previous reclosers and provide increased flexibility and ease of installation, testing, and adjusting.

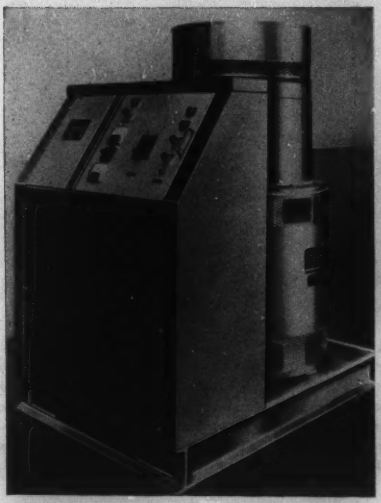


◄ Southern California Edison engineers check operating data on General Electric 230-kv 1,600-ampere air-blast power circuit breakers. Interrupting rating is 15,000 mva.



► This 230-kv 15,000-mva Westinghouse sulfur hexafluoride circuit breaker is shown beginning its journey to Pennsylvania Power & Light Company's Brunner Island steam–electric generating station near Harrisburg, Pa.

POWER



▲ Power circuit breakers at Westinghouse are now being built on a multi-station assembly line along which breakers weighing up to 22 tons are drawn by an underfloor drag line. Materials are preorganized before being brought to the assembly teams at their stations along the line.

▲ Vertical motor–generator that eliminates shaft deflection and, therefore, vibration has been developed by the Leach Corporation, producer of precise high-frequency power equipment for air and space support and check-out. The brushless, synchronous unit, also available for defense or industrial laboratory uses, will handle ratings from 125 to 175 kw.

► A 5,500-kw gas turbine being built by Westinghouse for the city of Austin, Minn., will be used for emergencies and for peaking service during the first 2 or 3 years following installation; later it will be used with a steam plant for combined-cycle operation.

▲ Recently announced by Allis-Chalmers Manufacturing Company is a contract to modernize an existing power plant of the Gulf States Utilities Company for operation of computer equipment. When completed, the Riverside Power Station at Lake Charles, La., will have the necessary controls to allow two Allis-Chalmers turbines (*above, left*)—a 35,000- and a 40,000-kw unit—to be automatically started when required for peak loads and shut down as the load decreases. The computer will calculate continuously the heat rates of the station so that the plant can be automatically regulated at all times to maintain desired conditions. (*Above, right*) Artist's conception of controls for "Systemation" project is shown. The new equipment is expected to be in service before the end of 1961.

RESEARCH

▲ An amplifying device with gain proportional to light intensity, this experimental cadmium sulfide field-effect transistor developed by General Motors Research Laboratories can perform photosensitive or high-impedance circuit functions not possible with conventional circuit elements. One such application is a simple circuit for direct conversion of light intensity to a proportional oscillator frequency.

▲ G. D. Oxx, Jr., of General Electric Research Laboratory measures the thermal expansion of Fernico-5. This new alloy, developed by Oxx, is of major significance in the electrical industry because it matches the thermal expansion of alumina, the ceramic that possesses probably the best combination of properties for general use in the electrical industry. The thermal expansion of alumina is much lower than that of metals and alloys normally used in metal-to-ceramic seals. Thus, it has not been possible to take full advantage of the high strength, high heat resistance, and excellent insulating properties of alumina. Fernico 5, however, now permits use of alumina in electron tubes, thermionic converters, capacitors, and high-temperature circuits.

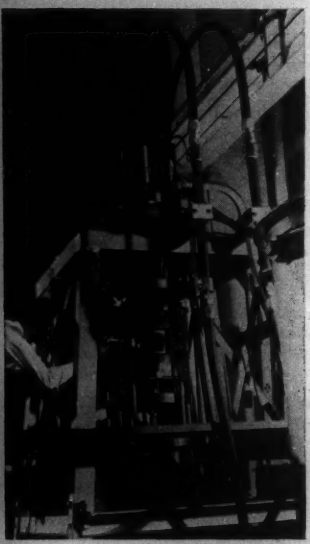
► Corning Glass Works began production on millions of tiny porous glass disks that serve as moisture getters in semiconductor devices. The "thirsty" glass used contains billions of submicroscopic holes that have an average diameter of about 1/6 microinch. Advantages include high mechanical strength and moisture-absorbing ability.

▲ If the rare metallic element niobium were purified in a conventional container, impurities would be transferred by the container itself. Here Tom Davies, of Minneapolis-Honeywell's Central Research Laboratories, looks through belljar as niobium (white ball in center of picture) is levitation melted. The purified material is used by Honeywell scientists seeking to improve the corrosion properties of metals.

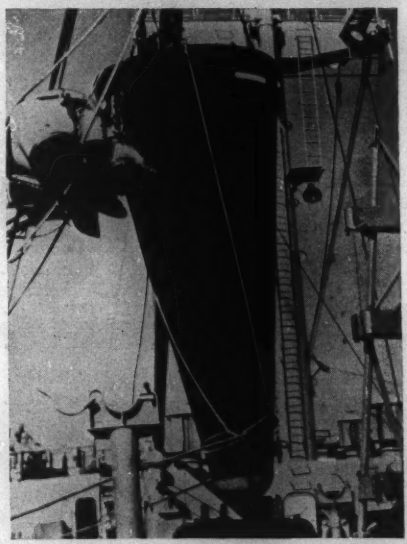
► Pilot and instructor discuss problems encountered during simulated flight of the F-100A Super Sabre jet through UDOFTT (Universal Digital Operational Flight Trainer, Tool), the new Navy and Air Force research device. UDOFTT was developed by Sylvania Electric Products, Inc., under contract from the U.S. Naval Training Device Center. The high-speed digital computer system can simulate conditions harmonious to any type of travel that can be reduced to a mathematical formula and stored in a computer.

◀ A new electrochemical determination of the faraday has been made at National Bureau of Standards. This is quantity of electricity associated with change of one equivalent weight of the reacting substance in any electrolytic process. Current dissolving measurable amount of silver is calculated from Ohm's law when *IR* drop across standard resistors is balanced against emf of standard cell.

► Within these Helmholtz coils at Kettering Magnetics Laboratory, GM Research Laboratories scientists have reduced earth's magnetic field to 0.0001 times its usual strength. Gyromagnetic ratios of ferromagnetic materials may be determined with extreme precision.



◀ A machine with the potential capability to supply a stream of gas at temperatures as high as 20,000 F and pressures as great as 15,000 psi has been devised by the Westinghouse Electric Corporation. The machine, an electric arc heater, can operate for sustained periods of time at an extremely low level of gas contamination. It has immediate application in a wind tunnel for missile testing. Also, it holds promise as a chemical synthesizer and as a furnace for processing metals with ultrahigh melting points. A prototype model of the machine has been operated at a power input of 1,700 kw, but a high of 30,000 kw is planned by Westinghouse.



▲ Corning Glass Works announced in May that antenna windows made of Multiform fused silica survived ballistic re-entry from space in an experimental ablative cone. One window can be seen clearly near base edge of General Electric nose cone, just retrieved from Atlantic Ocean. The Corning material has a stable dielectric constant and low loss tangent over a broad temperature range.

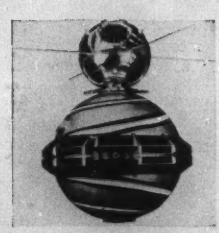
◀ Sun's surface is cool compared to heat being generated by unusual "gun" operated by Robert Fenity of Minneapolis-Honeywell's Central Research Laboratories. Temperature of metal being sprayed on ceramic material (*right*) is 20,000 F, compared with 10,000 F on sun's surface.

◄ Gold-plated cover is for Minneapolis-Honeywell's guidance system which performs electronic brainwork for National Aeronautics and Space Administration's Scout space vehicle. Gold was used on cover to reflect heat and protect system's sensitive electronic components.

▼ Dr. Herbert Friedman (*right*) and Joseph Nemecek, Naval Research Laboratory, assemble electronic gear in instrumentation section of an Aerobee-Hi rocket. In this experiment, performed in May, special telescopes installed in nose cone measured intensity of starlight in the far ultraviolet.

Official U.S. Air Force Photo

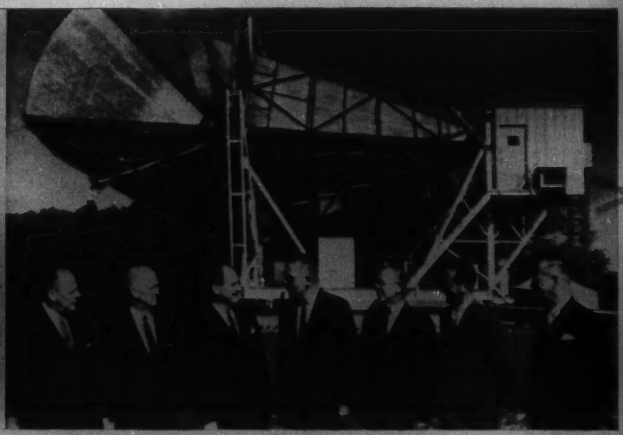
▲ This Floyd, N. Y., site of the Rome Air Development Center (RADC) was the first station to receive a message bounced off a man-made satellite. The radar picked up signals transmitted from the RADC Trinidad, B.W.I., site via balloon satellite Echo I in August. Here the Floyd antenna tracks Echo (the white streak).



◄ Drawing of Naval Research Laboratory's solar radiation measurement satellite bound in "piggyback" fashion atop Transit II-A satellite. After orbital injection, NRL package is released from Transit by spring force and travels on its own orbit as an independent experiment.

Official U.S. Navy Photographs

▲ H. E. D. Scovill of Bell Telephone Laboratories points out to R. W. DeGrasse an input co-ax of low-frequency traveling-wave maser. Designed specifically for satellite communication, this packaged 2-channel maser operates at a signal frequency of 2.4 kmc. The ruby-loaded 2-channel maser is part of low-noise receiving system used with horn-reflector antenna at Holmdel, N. J., to amplify weak microwave signals relayed from passive satellite sphere orbiting the earth at about 1,000 miles.

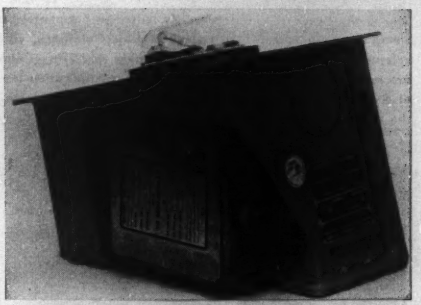


▲ Members of the Federal Communications Commission (FCC) are shown with T. K. Glennan, NASA Administrator, in photo transmitted via NASA's Echo I satellite. Picture was taken at Holmdel, N. J., where group observed satellite communications firsthand. Photo was transmitted by landline to Naval Research Laboratory at Stump Neck, Md., then bounced off Echo satellite back to Holmdel. Left to right are Commissioners J. S. Cross, R. H. Hyde, Dr. Glennan, FCC Chairman F. W. Ford, Commissioners R. T. Bartley, R. E. Lee, T. A. M. Craven.

◄ Built by General Electric, radio-command guidance system for Atlas ICBM pinpoints targets 6,000 miles away within less than a 2-mile circle. C. Whittington is shown checking airborne components of guidance system on Atlas at Cape Canaveral, Fla.

► New 2-foot-long device, developed by Raytheon Company, locks onto light reflected by satellite and tracks automatically, giving instantaneous data on location and tumbling. Engineers A. Krutchkoff (*left*) and W. Haywood are shown tracking Echo I.

► Atlas Optical Beacon, a product of Convair (Astronautics), is a sealed miniature all-transistor unit which provides accurately spaced, high-intensity light flashes for precision optical tracking of vehicles by ballistic cameras. Unit will withstand severe environments while operated from instant activate silver zinc battery.



▲ In 2 months, tiny RCA television camera tube, like the one shown, made more than 20,000 photographs from Tiros, weather satellite orbiting 450 miles in space. The rugged vidicon was designed and built by RCA Electron Tube Division to withstand severe shock and vibration encountered in missile launching. Satellite system was developed for NASA by RCA Astro-Electronic Products Division.

◄ Tiros television weather satellite, a duplicate of system placed in orbit on April 4, appears to hover over the Capitol dome as it is moved into the House Office Building for a briefing to the House Committee on Science and Astronautics. Unit was on its way back from Cape Canaveral, Fla., to the RCA Astro-Electronic Products Division at Princeton, N. J., for certain modifications in preparation for its use in a later stage of the Tiros program, sponsored by the National Aeronautics and Space Administration.

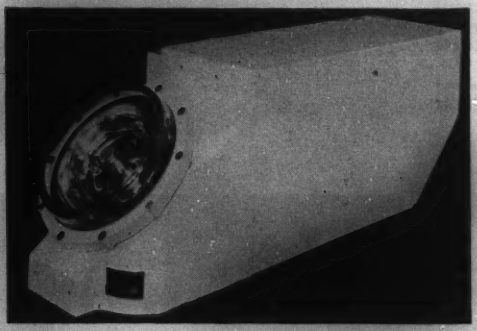
▲ Guidance brain for mammoth Titan missile gets final check at Aeronautical Division of Minneapolis-Honeywell by inspection group leader Bruce Paterson. This part of missile's electronics, called guidance reference system, provides major portion of electronic brainwork for first 2 minutes of flight of Air Force ICBM. The system supplies command signals to autopilot to guide missile on prechosen path from time of launch until missile's radio gudiance system takes over.

LIGHT

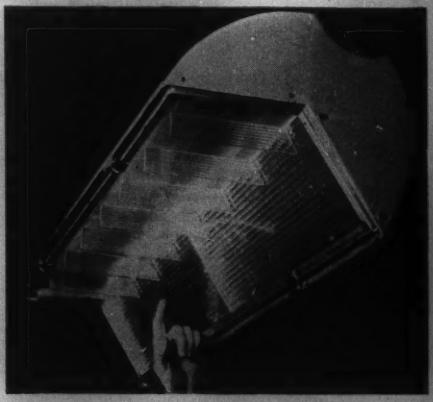
◀ Astrocon tube is so sensitive that it makes visible a single electron, released at tube's input by an individual photon, the smallest quantity of light. It operates upon a unique amplifying principle discovered at Westinghouse research laboratories 5 years ago. An object's image, so dim that it is invisible to the naked eye, is focused by lenses onto a photosurface. Photons arriving from the scene strike surface and eject electrons. Each electron is accelerated forward by 2,000 volts and strikes thin 2-layer film. More electrons are released and strike second film, where multiplication is repeated. By use of five such steps, plus final 20,000-volt boost, brightness amplification in the thousands is achieved at the output end.

U.S. Army Photograph

▲ Low-voltage high-pressure multicathode xenon light source, designed to provide greater illumination over a wide area, is being tested by U.S. Army Engineer Research and Development Laboratories (USAERDL), Fort Belvoir, Va. As a light source, xenon may be 100 times brighter than tungsten lamps. Unit being tested is experimental model built by Duro-Test Corp.



▲ Optical beacon, to be carried in airborne missiles, emits precisely timed flash that can be photographed up to 400 miles away. It will permit more accurate studies of missiles launched at night. Developed by Battelle Memorial Institute for Grimes Manufacturing Company, the beacon produces flashes of 0.001-second duration at 500-millisecond intervals with an accuracy of ±0.001 second for a period of 25 seconds.



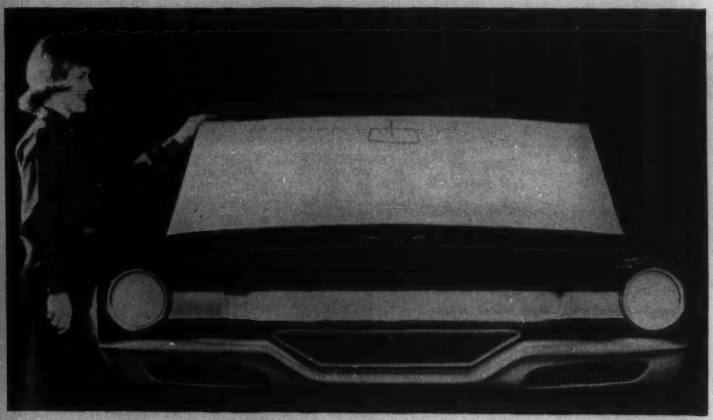
▲ Fluorescent luminaire designed by the Westinghouse Electric Corporation for use along ship canals uses both reflectors and refractors to confine light to the canal banks, thus eliminating glare from the water.

U.S. Army Photograph

◀ Shown operating target tank at distance of 1,000 yards, searchlight developed by USAERDL can be changed easily by rotation of cylinders about lamp from visible to infrared mode of operation, and from concentrated beam to spread beam. Infrared–visible searchlight, using xenon compact arc lamp and operating directly from tank voltage, has a peak beam candlepower of 140 million, and a beam width of 1 degree.

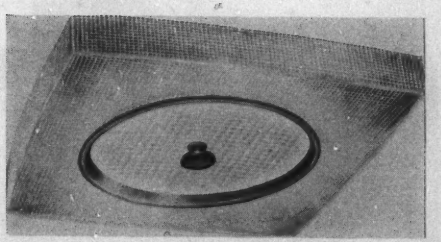
◄ "Sun Gun," light source for 8mm movie makers, was introduced by Sylvania Electric Products, Inc. It is a halogen lamp in a 2¾-inch reflector, and provides the same effective light as an 18-inch light bar containing four R-30 photoflood lamps.

► Small ribbons of copper are attached to RCA's electroluminescent panels by Emma Kushner to provide electrical connections. Phosphor-coated panels, which emit a soft glow of light, are now in pilot production. Completed "Panelray" units shown in foreground are ready for shipment to equipment manufacturers.

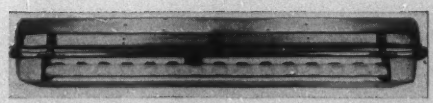


◄ Compact fluorescent lighting system with brightness level 338% greater than any fluorescent unit commercially available was demonstrated by Sylvania Electric Products, Inc. One potential of the new system is an automobile headlight. The unit permits even distribution of light to front and to sides of vehicle, with a very sharp vertical cutoff, thus allowing the driver to see objects more clearly. It also keeps glare from the eyes of oncoming driver. The new linear headlight is shown extended across grille of car mock-up between the conventional incandescent headlamps.

► The Holophane no. 500 indoor luminaire features attractive appearance and uniform illumination. Socket is mounted on angle strap for correct setting with either 100- or 150-watt incandescent lamp.



◄ Internally ballasted pole-top-mercury luminaires are manufactured by Line Material Industries. These fixtures, designated Line 2E2, are designed for high-level lighting of streets, highways, and parking areas. They accommodate clear or color-improved mercury lamps rated 700 and 1,000 watts and produce IES types III and IV light patterns.



▲ Thermoelectrically cooled fluorescent luminaires, manufactured by Line Material Industries, achieve maximum light output over wide temperature range. At 77 F ambient, light output of cooled luminaire is 72% higher than identical luminaire without the device. Light output is nearly constant throughout ambient temperature range of below zero F to above 77 F.

▲ IBM 870 document writing system provides output in form of typewritten script, punched cards, and punched paper tape. In system shown, data is recorded on punched cards and as typewritten copy simultaneously. A paper tape punch can also be included to yield a third form of simultaneous output.

▲ All-magnetic computer, designed and developed by the Stanford Research Institute under the sponsorship of the United States Air Force Cambridge Research Center, utilizes Multi-Aperture Devices (MADs) in its construction. Advantages include small size, low expense, versatility, and high reliability.

◄ Digital data recorded at random on single 1,500-foot reel of magnetic tape over periods up to 250 calendar days is possible with this incremental recorder from Minneapolis-Honeywell. With minor modifications, the recorder combines compatible computer tapes from random data sources.

▲ For use in Convair 600 jet transport, "mach-trim" digital system automatically compensates for nose-down effect or "tuck-under," occurring in swept-wing aircraft as they approach speed of sound. Computer unit was built by AiResearch Manufacturing Company and amplifier (*left*) by Convair, a division of General Dynamics Corporation.

◄ "Conversation" between sending and receiving units of IBM 1001 data transmission system takes place over existing telephone lines. When operator has dialed central office, she inserts punched card (*top left*) containing fixed numerical data into card carriage, which is moved to left (*top right*), then released on audible signal. It then returns to right-hand position, reading and transmitting data from card at about 12 columns a second. Variable numerical information may be entered manually from keyboard (*lower left*). Data is received at central station, where modified IBM card punch (*lower right*) simultaneously punches data into cards ready for processing.

COMPUTERS

► R. K. Gessford, of Sylvania Electric Products, Inc., demonstrates pair of low-cost, compact, electroluminescent read-out devices capable of performing the logic and memory functions of digital computers. The devices make possible substantial progress in design of electronic equipment used in data processing, radar, countermeasures, medicine, air and sea traffic control, and entertainment.

▲ New technique for fabricating miniaturized memory units providing densities as high as 2,000 bits per cubic inch has been developed by CBS Electronics Division of the Columbia Broadcasting System, Inc. This 16-bit test cube is built up sandwich style with four embedded ferrite cores in each plane. Same technique can provide 10,000 to 15,000 bits in a space not much larger than a slice of bread.

► Electronic computer which works out the proper "recipe" for making steel in the basic oxygen furnace has been installed at the Aliquippa, Pa., works of Jones & Laughlin Steel Corporation. The special purpose analog computer calculates the proper proportions of hot metal, scrap, and lime to be charged into the furnace so any desired type of steel may be tapped at the desired temperature. The tapping or finishing temperature in this new steelmaking process plays an important role in the quality of the product.

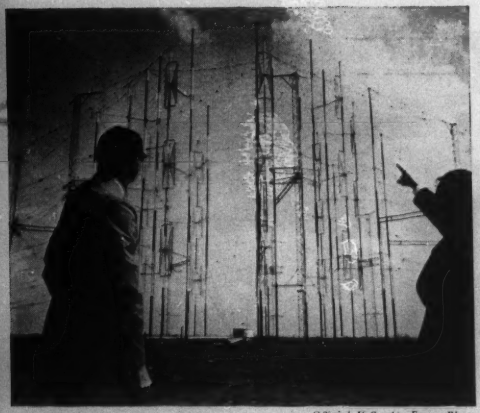
◄ Far-reaching achievement at Rome Air Development Center (RADC) is the Russian Translator, which translates up to 1,600 words a minute into readable English. Scientists expect to replace human operator with automatic print reader and lower translation costs from 1/4 to 1/20 cent per word. Logic circuits are being developed to improve machine's syntax and grammar.

► In the ASROC fire-control system, digital computer receives electric signals of target course and speed, wind direction and speed, and attack ship course, speed, pitch, and roll. System developed for Navy by Librascope. Minneapolis-Honeywell is prime contractor.

Supersonic Wind Tunnel

(*Upper left*) Work on one of world's largest rotating machines is nearing completion as the supersonic wind tunnel at Tullahoma, Tenn., is being readied for operation. Shown here is portion of giant 287-foot-long supersonic compressor unit built by Westinghouse Electric Corporation. Four compressors with a total of 21 separate stages comprise this entire rotating mass which, in turn, is coupled to four giant motors. (*Left*) Westinghouse 4-motor drive system develops 215,000 hp. The motors, connected to two compressors, are now producing transonic wind velocities and soon will be generating speeds exceeding 3,000 mph in the supersonic wind tunnel. Two of the synchronous motors are rated at 83,000 hp each and two at 25,000 hp each. Larger units stand 21½ feet high and weigh 225 tons. The 122-ton rotors spin at a rate of 600 rpm. (*Above*) With these instruments and controls at the Arnold Engineering Development Center, flight conditions are simulated in the huge wind tunnels located behind the panel.

▲ Vertical steel vanes decrease turbulence in the air flow as its direction is altered at corners of supersonic wind tunnel. Diameter of tunnel is 47 feet at this point, and ranges from 62 to 32 feet at other sections. (*Above, center*) Behind huge "grille" are coolers through which more than 65,000 gallons per minute of water will be pumped to absorb heat from the air in the wind tunnel. When tunnel is completed, Westinghouse compressors will drive air through the test section at velocities from 1,000 to about 3,000 mph at simulated altitudes of more than 100,000 feet. (*Above, right*) Inside supersonic wind tunnel, scaffolding supports workers installing layer of patchwork-like insulating material which will absorb temperatures as high as 650 F. Tunnel diameter at this point is about 55 feet.



Official U.S. Air Force Photo

▲ This Wullenweber guide-type antenna at the Rome Air Development Center's Ava, N. Y., site is a vertical polarized type, transmitting between 7 and 14 mc. It transmits long-range signals for testing purposes with horizontal beam steering in increments of 20 degrees.

Official U.S. Air Force Photo

▲ At Rome Air Development Center's Verona, N. Y., test facility, 20 different types of radars covering the entire usable radar spectrum are employed for testing new electronic countermeasures systems, components, and techniques.

Official U.S. Air Force Photo

◄ Rome Air Development Center's Trinidad, B.W.I., site used the *FPS-44* for its role in pretesting Ballistic Missile Early Warning System site at Thule, Greenland, and tracking missile and satellite launches from Cape Canaveral, Fla.

▼ Antenna developed by the National Bureau of Standards (NBS) promises to provide science with a new tool for experimental studies of the ionosphere. Without benefit of electric or mechanical moving parts, it scans a 42-degree azimuthal arc and can pinpoint instantly the direction from which the scattered signal arrives. The system, consisting of seven 5-element Yagi antennas, is installed at Table Mesa, a field station near the NBS Boulder, Colo., laboratories.

Official U.S. Air Force Photo

◄ Towering above the Alabama countryside is the antenna reflector for the prototype *AN/FPS-24*, built by General Electric as one of five frequency diversity search radars for the Rome Air Development Center. The new radars have powers ranging from 5 to 15 times as great as conventional types. These sets are reported to give radar the ability to "find" any known manned aircraft.

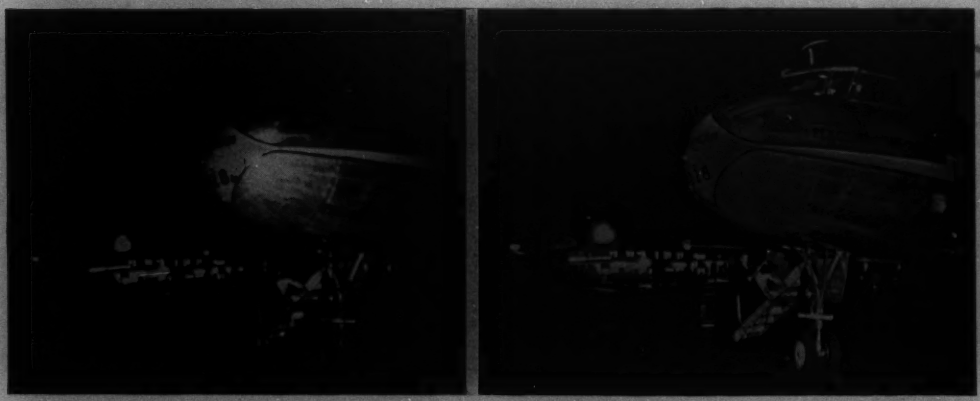
TUBES

▲ T. H. Rogers *(left)*, engineering director of Machlett Laboratories, and W. E. Stevenson, president, examine X-ray image intensifiers. Tube increases brightness of fluoroscopic screen 3,000 times and makes possible X-ray movies of the heart and other body functions with greatly reduced radiation exposure.

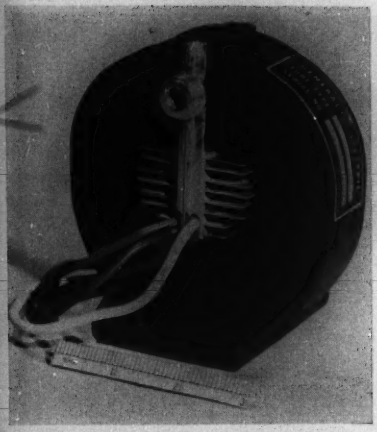
▲ Intensifying light tube radiation by electronic means, Westinghouse tube produces image with brightness increased by 2,500 (minimum) for actinic blue input radiation, by 1,000 for input radiation at a color temperature of 2,870 K.

◄ Model holds a GL-7629 image orthicon, General Electric's new "see in the dark" television camera tube. The tube won an Academy of Television Arts and Sciences "Emmy" award for 1960, with a citation ". . . for permitting colorcasting in no more light than is needed for black-and-white."

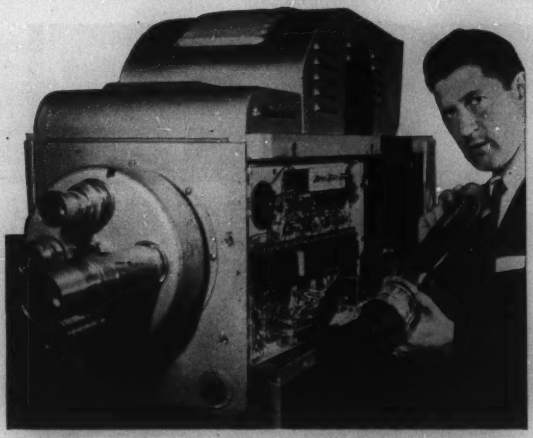
▲ New Westinghouse silicon transistors have maximum collector current ratings of 30 amperes, power dissipation of 250 watts, and collector–emitter voltages up to 100, 150, or 200 volts. The units are available in three series, with collector current ratings of 10, 15, and 20 amperes, respectively, at a current gain of 10. The junction operating and storage temperature range is —65 to 150 C.



▲ Gain in sensitivity of the new General Electric Company GL-7629 tube over the standard GL-5820 image orthicon is shown in photographs above. At left is monitor presentation received from a television camera equipped with the GL-5820, while at right is monitor presentation from a camera equipped with the GL-7629. Available light at the airport and lens settings on both cameras were equal.



▲ General Electric Company type Z-5424 voltage-tunable magnetron produces 50 watts minimum over a 2,900- to 3,200-mc frequency range. New tube is complete r-f power source, for use in space telemetry, rapidly tuned radar, and electronic countermeasures.



▲ High-sensitivity color television camera tube, held by J. B. Rogers, has been introduced by the RCA Electron Tube Division for telecasting night sports events. The network and several leading television stations will equip their cameras with the new tube for after-dark pickups of baseball and football games, as well as trotting races.

▲ Television picture tubes which have a glass safety panel bonded directly to the tube face plate are mass produced by Sylvania Electric Products, Inc. Receivers using these tubes require no separate safety glass. "Dead space" between tube and safety panel is thus eliminated, with clearer, sharper pictures resulting. Also, sharper corners and the relatively flat face of the "Bonded Shield" tubes permit viewers to see more of the picture as the studio camera transmits it.

▲ Cathode-ray bulb with 35,000 wire conductors embedded in 3- by ¼-inch faceplate was developed for high-speed electronic printing. Corning Glass Works produces the vacuum-type bulb for use in Videograph process developed by the A. B. Dick Company. Bulb design was a co-operative effort by Corning and Sylvania Electric Products, Inc. Sylvania processes the finished tube.

► Operator loads miniature tubes for radio and television sets into this new aging machine developed by the RCA Electron Tube Division. The device is capable of aging 2,000 tubes per hour. In electron-tube manufacture, aging is a process of operating tubes for a short time under controlled conditions to improve stability and performance. Operator inserts tubes into sockets which are conveyed through the complete aging schedule and automatically removed from the machine.

▲ The voices of telephone customers are carried through neon-gas tubes that make up "switching network" shown. Tubes are used to connect one telephone to another, a task that until now has been performed by relays. An installer removes tray of tubes while engineer observes. Dots of light at right are tubes in use at the moment to set up telephone connections.

▲ E. J. Miller, Bell Laboratories, inserts into place one of thousands of printed circuit boards used in system. Wiring is printed or plated on board to connect components, and metal "teeth" on end of board make electrical connection with rest of equipment.

Electronic Central Telephone Office

A customer trial of the world's first electronic telephone central office has been started at Morris, Ill., by Bell Telephone Laboratories and the Illinois Bell Telephone Company. It performs electronically all the functions in handling of telephone calls. It was described by Bell Laboratories President J. B. Fisk as ". . . a totally new system making possible a variety of new services which will double the flexibility and hence the potential value of each customer's telephone."

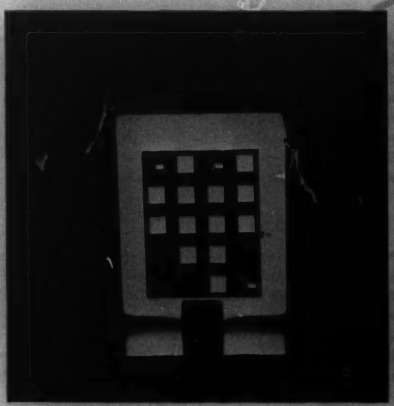
The electronic central office (ECO) permits trial users to use home extension phones as intercoms, simply by dialing two digits; reach frequently called numbers by dialing only two digits instead of seven; have incoming calls routed to another phone when the original called line is busy; dial a code which causes all subsequent incoming calls to be automatically transferred to any other number. Other services expected to be introduced later will permit many of the trial customers to allow a third party to be called into an existing conversation, and to permit an immediate connection to a busy line as soon as the line becomes available. Telephone engineers are now investigating ways to provide some of these services through existing systems.

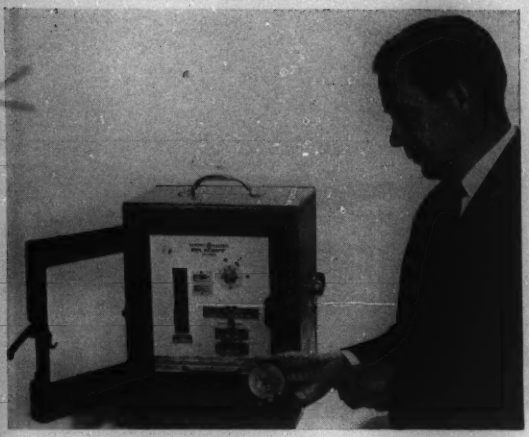
One key to the success of ECO is that it uses stored program control to perform its job; that is, each action of the machine is determined by instructions stored in its memory. The ECO operates with such speed that it has enough spare time to check its own circuits continuously. When it discovers a fault, it locates and diagnoses the trouble and, in some cases, even makes the necessary corrections.

Although some of its basic theory has been known for many years, ECO became feasible only with the invention of the transistor and other semiconductor devices and with the development of high-speed high-capacity memory systems. The Morris ECO uses some 12,000 transistors, 105,000 diodes, 23,000 tiny neon-filled tubes, and tens of thousands of other electronic components.

◄ Bell Laboratories engineers prepare to install cathode-ray tube in flying-spot store, a photographic memory device capable of storing 2¼ million bits of information. System operation is controlled by program of binary words in this semipermanent memory.

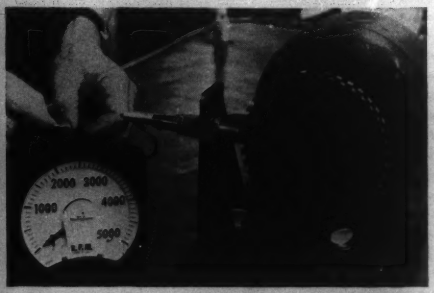
► Photographic plate used in ECO is examined in darkroom by C. A. Lovell, left, and R. W. Ketchledge, two directors of switching systems development. A bit of information is recorded on plate in form of a tiny dot, or absence of a dot, in any particular location. Each square on plate has room for 33,000 bits.





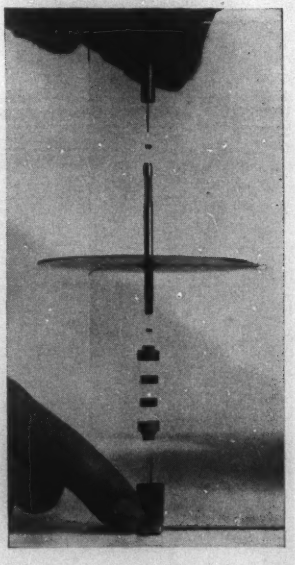
▲ The General Electric PULscript recorder and translator system receives and records electric impulse totals on tape which can either be read visually or run through the translator to obtain punched cards, punched tape, or magnetic tape for automatic data processing. The recorder prints translucent Arabic numbers through which light is passed in the translator to operate sensitive solar cells.

▲ A. R. Christman, specialist/product planning, demonstrates easy accessibility of solid-state logic elements—plug-in cards used in General Electric's new supervisory control equipment. Use of transistors promises long equipment life, flexibility in enclosure design, and weight and space savings.



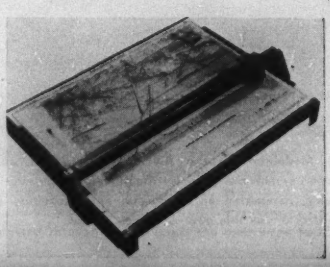
▲ Type K-241 speed-indicating instrument from Westinghouse is used with small steam or gas turbines. The principal advantage of the electromagnetic device is that no mechanical connection is required between it and the rotating shaft. It can be adapted to almost any desired rpm range.

► Magnetic bearing systems of a new type supersede ball-and-jewel bearings in single-phase 120/240-volt watt-hour meters announced by Westinghouse. Disk-and-shaft assemblies are supported by magnetic repulsion between two rings of barium ferrite. Mounted with their fields in opposition, these rings serve as the two "working surfaces" of a frictionless thrust bearing. Supplying the lateral forces needed to restrict horizontal movement are stationary pins within graphite journals at the upper and lower ends of the shaft.

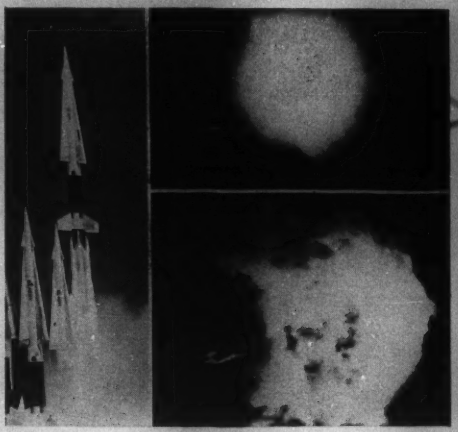


◄ In Minneapolis-Honeywell's solid-state load and frequency control system, modular units dispense with vacuum tubes and moving parts such as slidewires, motors, and gear trains. Heart of system is a control amplifier which replaces the slidewire servo.

► Airborne dead reckoning tracer, developed by Servo Corp. of America, consists of an airborne electromechanical computer and plotting machine with curve follower feature. It computes and displays latitude and longitude on counter-type indicators, while tracing aircraft's positions on Lambert conformal chart.



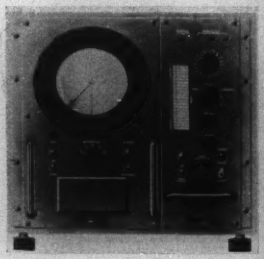
▲ Fire-control radars for the Navy's surface-to-air Tartar missile are shown on the new guided missile destroyer *Charles F. Adams*, commissioned in September. Developed and produced by Raytheon Company for the Navy's Bureau of Weapons, the radars help guide the Tartar missile, despite enemy evasive tactics or jamming devices. The *AN/SPG-51* can be used as part of the ship's over-all fire-control system to fire the vessels conventional guns. Tartar is effective against low-flying and medium-altitude targets.

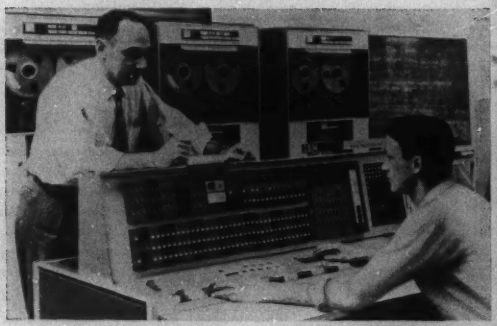


▲ In demonstration last August, U.S. Army's Nike-Hercules air defense missile "killed" another Hercules 11 miles above White Sands Missile Range, N. Mex. A Hercules missile is seen in picture at left, rising from its launch pad. At upper right, defending missile is shown exploding as it intercepts target missile, small object in left side of picture. In lower right picture is shown the actual "kill." Test was conducted by Army personnel and Bell Laboratories and Douglas Aircraft Company engineers.

▲ Modulator for the *AN/APS-95* airborne early warning radar system designed by the Hazeltine Corporation is shown being assembled on production line. Hazeltine is the prime contractor for this new Air Force system.

► Under terms of an Air Force contract, Servo Corporation of America will produce a newly designed uhf Doppler direction finder for Rome Air Materiel Area. Engineered by Servo for military use, it embodies important advances in accuracy, speed of operation, reliability, and flexibility. Fully sensed, stable bearings are displayed in 0.1 second as a sharp strobe line on cathode-ray tube with calibrated azimuth scale.



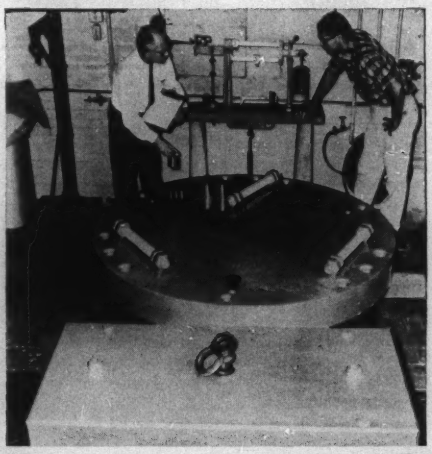


▲ Data-processing phase of the Air Force's Ballistic Missile Early Warning System (BMEWS) includes general purpose computer apparatus subsystem called Missile Impact Predicter Set (MIPS). Sylvania Electric Products, Inc., is responsible for design, manufacture, and installation of the data-processing phase. MIPS is made up of two standard IBM Corp. solid-state computer systems, and specialized "real-time" equipment designed jointly by IBM and Sylvania.

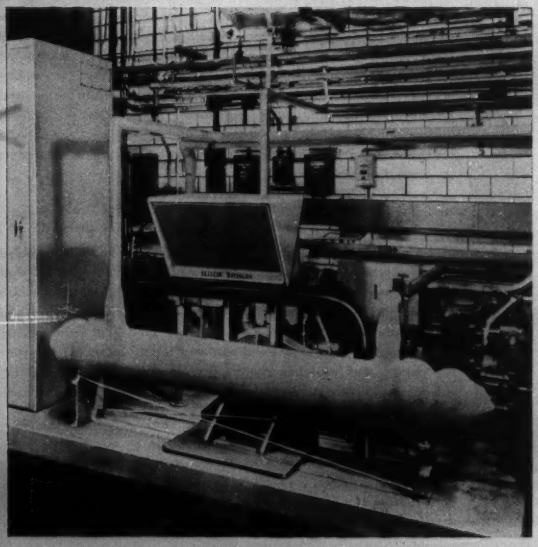
◀ Instrument constructed by National Bureau of Standards provides continuous strip-chart fade-rate recordings of received radio signals. The number of times per second that the signal envelope crosses the average signal level is taken as the fading rate; comparisons of fading rates so defined can conveniently be made for various propagation conditions and paths.

▲ Highly accurate resonant cavity X-band dielectrometer for measuring electrical behavior of radomes and antenna covering materials at temperatures to 2,700 F has been developed at the Boeing Aero-Space Division. It measures dielectric constant to within 1% and also measures loss tangent.

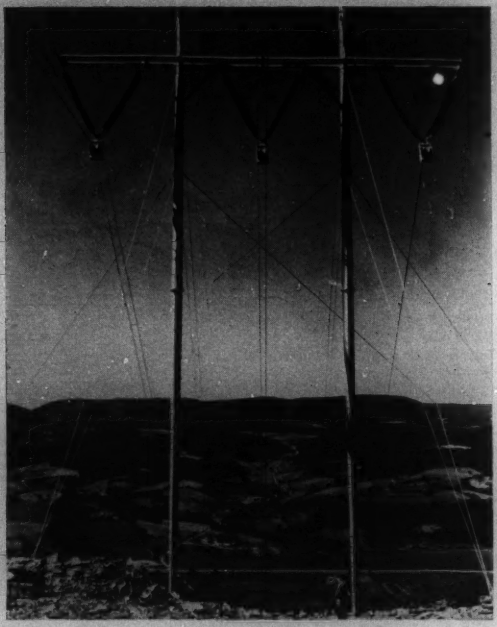
◀ The type 1531-A Strobotac, made by the General Radio Company, represents the most important advance in commercial stroboscope design since 1935, when the company first introduced the Strobotac stroboscopic tachometer. The new instrument offers a combination of performance characteristics not hitherto available in any commercial stroboscope.



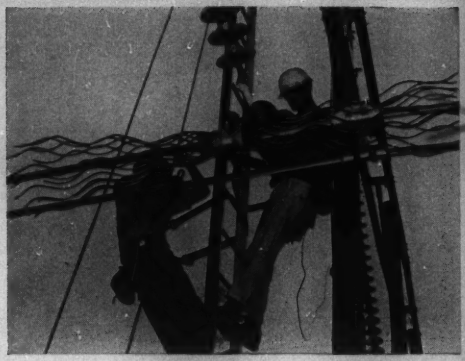
▲ Precision weighing is performed at National Bureau of Standards, Washington, D. C., on weights and parts for the highest capacity dead-weight testing facility, now under construction at the Electronics and Instrumentation Division of the Baldwin-Lima-Hamilton Corporation, Waltham, Mass. The facility will calibrate load cells used in both development and operational firing of such missiles as Atlas and Titan. It will also serve as a primary standard for measuring applied loads in tension or compression from zero through 250,000 pounds, with an expected accuracy of ±1/100 of 1% of applied load anywhere in the range.

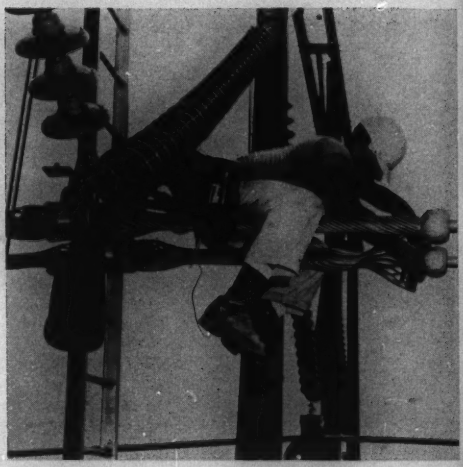


◀ Continuous on-line analysis of several chemical elements is possible for the first time through use of General Electric's X-ray emission gage. It consists of an electronic control cabinet that houses all power and measuring components (*left*) and a measuring head that houses X-ray tube and other analysis components (*center*). Fluid material being analyzed, in this case, is passed through a pipe under the measuring head.



▲ Technical achievements as vast as the mountains it crosses are represented by this 460,000-volt electric transmission line which was placed in service in the Fall of 1960 by the Pennsylvania Electric Company between Claysburg and Saxton, Pa. The first power line to operate at this extra-high voltage, the 13-mile line spans the beautiful Cove Valley being viewed here from a ridge of the towering Allegheny Mountains by D. L. Berkey, a Windber, Pa., engineer. The line was hailed in dedication ceremonies as additional evidence of the superiority of United States investor-owned utilities over the government-owned Soviet systems as its operating pressures and size far exceed anything in the Soviet, or any other country. The following manufacturers contributed to construction of the line: General Electric Company, Ohio Brass Company, Aluminum Company of America, Kaiser Aluminum and Chemical Corporation, Pennsylvania Transformer Division of McGraw-Edison Company, I-T-E Circuit Breaker Company, Preformed Line Products Company, Union Metal Manufacturing Company, Rilco Laminated Products, Inc., Hughes Brothers, Inc., Bethlehem Steel Company, and Copperweld Steel Company. Construction was shared by the Sordoni Construction Company and Day & Zimmerman, Inc.



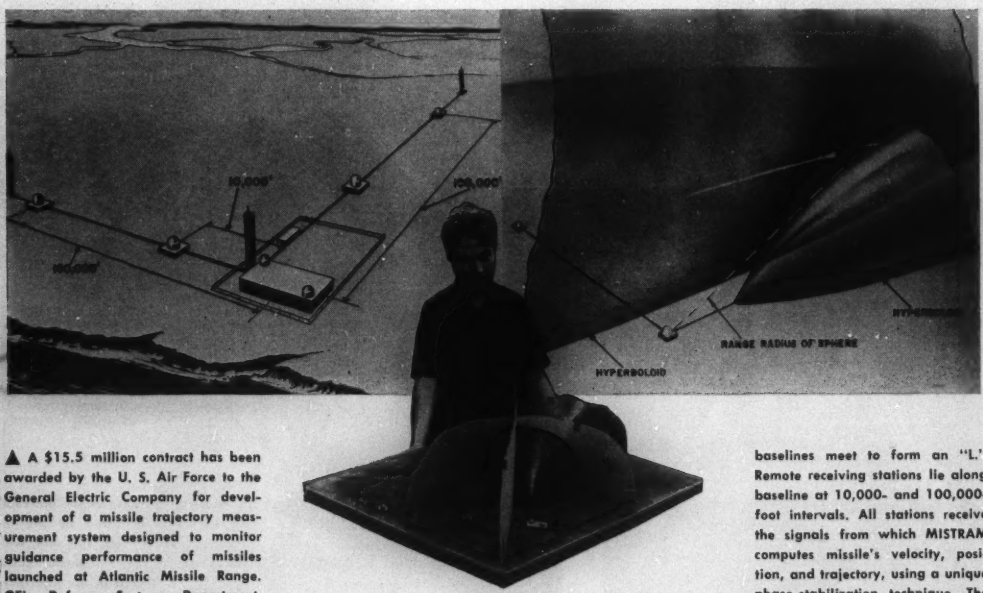


▲ When Penelec engineers threw switch to energize 13-mile 460-kv experimental line to study specially made components under ehv conditions, Preformed Line Products Company armor rods, armor-grip suspension (AGS) assemblies, spacers for bundled conductor, corona spheres, and other products played an important role. Two photographs shown were taken during the clipping in of a 2-conductor bundle of 1.75-inch ACSR expanded. They show rods being "wrapped" on and corona spheres secured. Attachment of the AGS assembly is made to a special clevis, which in turn is secured to the vee-string yoke plate.

◄ This 7,500/9,375-kva 67- to 13.8-kv 3-phase vapor/gas-cooled transformer built by Westinghouse was energized by the Gulf States Utilities, Beaumont, Texas, on July 6, 1960. This unit, which features gas-insulated load-tap-changer (LTC) equipment, carried its load on July 7. Fluorocarbon compound used in the transformer is nontoxic, fire and explosionproof, and totally inert. It has excellent cooling and insulating characteristics and together with SF_6 gas, operates effectively at pressures low enough to permit use of conventional transformer tank design.

▲ William Case of the National Bureau of Standards (NBS) Radio Standards Laboratory at Boulder, Colo., adjusts the local oscillator in an experimental setup for evaluating the tensor permeability properties of ferrite materials. The ferrite (in a cavity at the center of the electromagnet) is measured at a frequency of 1,060 mc. The Radio Standards Laboratory is expanding its program of radio standards research and calibration services.

▲ David Russell adjusts "magic T" input to detector of NBS high-frequency piston attenuator developed by Radio Standards Laboratory. At right is large trombone phase shifter used in this dual-channel system.



▲ A $15.5 million contract has been awarded by the U. S. Air Force to the General Electric Company for development of a missile trajectory measurement system designed to monitor guidance performance of missiles launched at Atlantic Missile Range. GE's Defense Systems Department, Syracuse, N. Y., will develop and install what is called a Missile Trajectory Measurement System or MISTRAM. Preliminary planning is now under way. The basic system is expected to be ready in 1962. Later an even more accurate system is planned for operation. The basic system, however, will remain an integral part of the final system. Its installation will be in the vicinity of Cape Canaveral, Fla., then additional outlying stations will be added on downrange island sites and on the East Coast of the United States. (*Left*) Layout shows central station, foreground where baselines meet to form an "L." Remote receiving stations lie along baseline at 10,000- and 100,000-foot intervals. All stations receive the signals from which MISTRAM computes missile's velocity, position, and trajectory, using a unique phase-stabilization technique. The system will give extremely precise readings on a missile's flight. MISTRAM performs these calculations by measuring missile's range from central station, and the difference between this range and the range from each remote station. (*Right*) Measurement of range describes a sphere to the system (dotted white line) and each range difference describes a hyperboloid of revolution. Picture shows hyperboloid on right like a cone and hyperboloid on left as broad and flat. Intersection of these three surfaces in space indicates missile's position. Scale model is shown in inset.

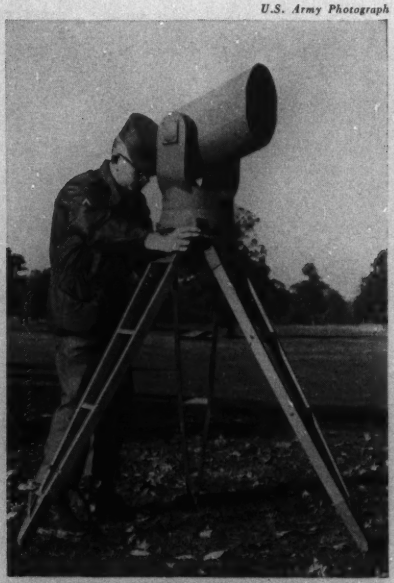
INSTRUMENTS

▲ New type "brain" for supersonic aircraft is checked out on a United States Air Force F-101 Voodoo jet interceptor. Developed by Minneapolis-Honeywell, the brain's technical name is Adaptive Flight Control System. This autopilot not only controls the plane, but also has its own electronic "intelligence" and, like man, adapts itself to its own environment.

U.S. Army Photograph

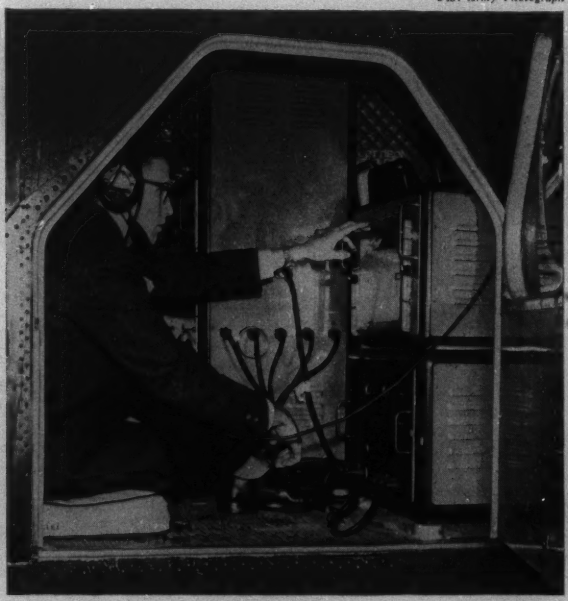
▲ Developed by U. S. Army Engineer Research and Development Laboratories and American Bosch Arma Corp., new land navigation system consists of four lightweight units that provide constant heading and position information. Direction to the home base, as well as distance and direction to the destination are available on demand. Units include a gyrocompass, analog computer, distance data transmitter, and power supply.

U.S. Army Photograph

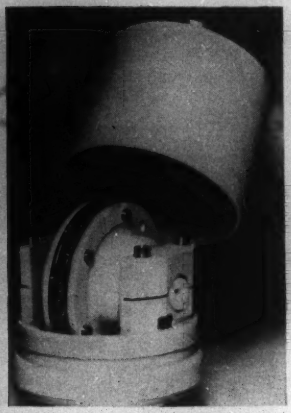


▲ An automatic tracking theodolite to provide a rapid method of extending geodetic control has been developed by the U. S. Army Geodesy, Intelligence and Mapping Research and Development Agency. Capable of automatically pointing on stationary targets and tracking fast-moving airborne lights, it will be used primarily by field artillery units and by topographic units of the Corps of Engineers.

U.S. Army Photograph

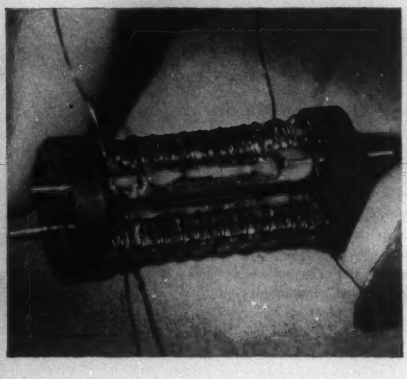


▲ An airborne tellurometer, an electronic distance-measuring instrument designed to increase range and circumvent former restrictions to line-of-sight measurements, is being tested by the U. S. Army Geodesy, Intelligence and Mapping Research and Development Agency, Fort Belvoir, Va. Master equipment is shown mounted in a plane.



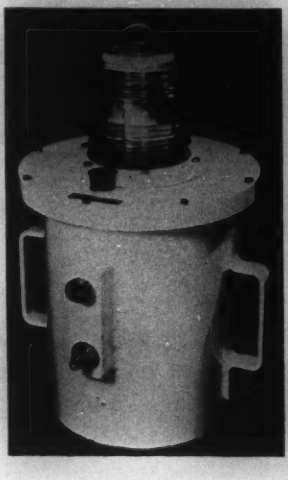
◄ Tiny gas bearing gyro is dwarfed by a human hand. Shown is ceramic spin motor of Minneapolis-Honeywell's superaccurate space guidance gyroscope about to be encased in ceramic gimbal. Precision ceramics made possible the first miniature application of gas bearing in gyroscopes.

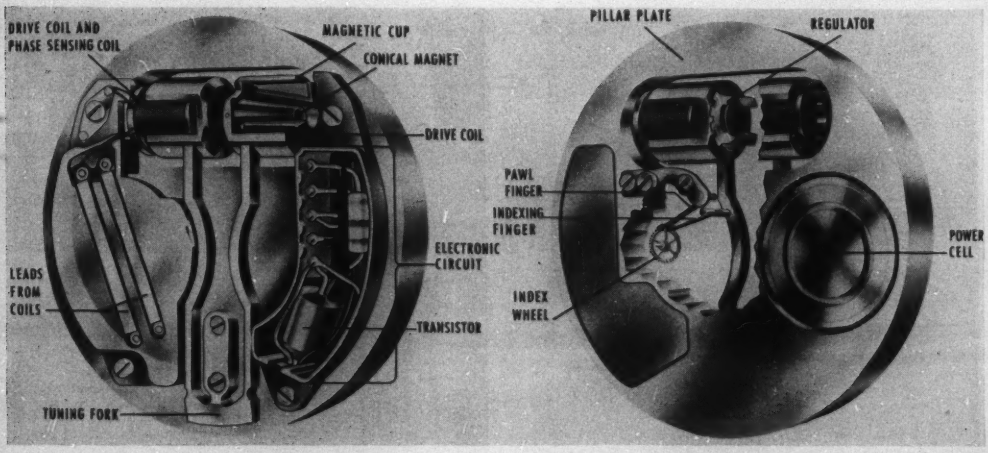
► Motorola battery-operated transistorized electronic d-c multimeter provides nine voltage ranges, with full-scale readings of 100 millivolts to 1,000 volts. There are 21 current ranges, providing full-scale readings from 1 microampere to 300 milliamperes. Five resistance ranges are provided with center-scale readings from 10 to 100,000 ohms.



► A prototype nuclear bomb alarm system has been installed along East Coast for U. S. Air Force by Western Union. Three or more nuclear blast sensors, pole mounted, surround each target area.

◄ The ferreed, developed at Bell Telephone Laboratories, is a very fast electromechanical switch with metallic contacts, requiring no holding power. In the 2-branch ferreed pictured, two ferrite bars, two glass-sealed magnetic reed switches, and two plastic end pieces comprise the magnetic circuit. Control pulses of 5 μsec will switch the magnetic material.

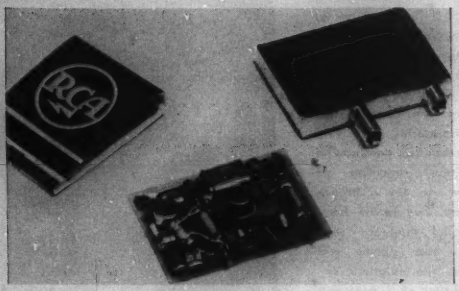




▲ Line drawings of Accutron show principal components of unique electronic timepiece created by the Bulova Watch Company, Inc. Drawing at left shows dial side of Accutron movement with tuning fork assembly in center including a cutaway of one coil showing one of the conical magnets and, at the right, basic elements of the electronic circuit. Drawing at right shows rear of mechanism, with simplified drawing of indexing components, the power cell in its recess, and regulator used by jeweler to change frequency of tuning fork.

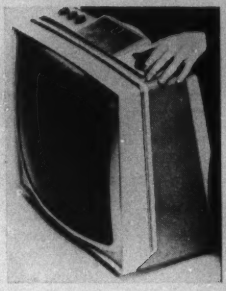
◄ R. F. McCall demonstrates Motorola's MOTRAC Universal Railroad Radio. The transistorized unit can operate directly from either 64- or 12-volt d-c power sources. By means of a single switch, the one-piece unit can be used in engine, caboose, or in maintenance-of-the-way operations.

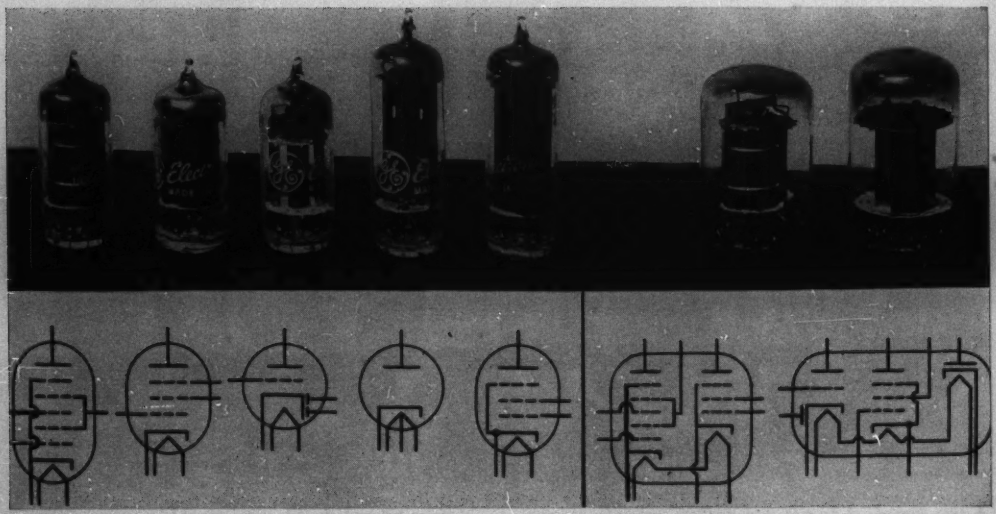
► Selective voice communication to more than 7,500 persons is provided with Motorola's recently announced radio paging system. Operating on standard mobile radio vhf bands, it permits one-way communication between a central base station and individuals carrying the compact "Handie-Talkie" radio paging receivers. When an individual is paged, an alerting tone sounds in his receiver. The private voice message follows. An audio output of 500 milliwatts is provided by the 14-ounce pager, which can be worn easily in a pocket or clipped on a belt.



► Sylvania has introduced two 19-inch portable television receivers featuring reflection-free screens. The screens are specially treated to trap and diffuse outside light and eliminate reflections.

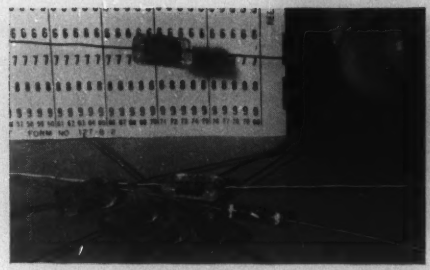
◄ Half-ounce transistorized radio transmitter was developed by RCA's Astro-Electronics Division to send tracking signals back to earth from the huge Echo balloon satellite placed in orbit by the National Aeronautics and Space Administration.



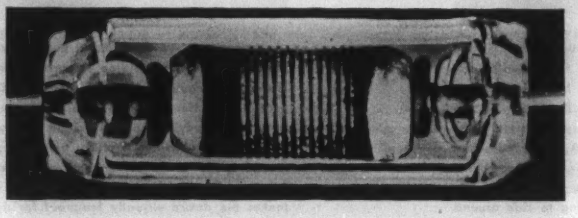


▲ Two "compactrons," a major electronic development by the General Electric Company, are shown (*right*) in comparison with the five miniature tubes they replace (*left*) required to perform identical functions in a radio receiving set. The compactrons combine, in two units, all of the functions of the *12BE6, 12BA6, 12AV6, 35W4,* and *50C5,* shown left to right. These two and others in development will permit manufacturers of radios, television receivers, and other home-entertainment equipment to build more compact sets.

▲ Technique for packaging microminiature electronic circuits on a series of tiny stacked wafers was announced by Sylvania Electric Products, Inc. The Sylvania Microminiature Module will find initial application in command guidance, communications, digital control, and other electronic circuits within missiles and satellites.

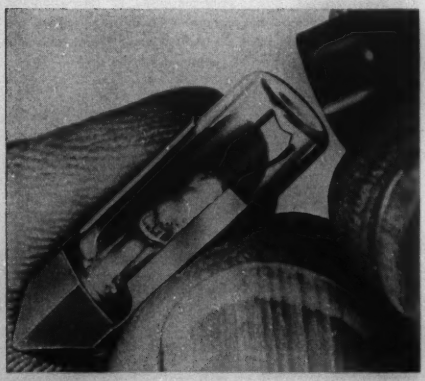


▲ Fusion-sealed glass capacitors like these will fly in Minuteman missiles. A contract to develop fixed glass capacitors with reliability of 99.9994% over 1,000 operating hours was awarded to Corning Electronic Components by Autonetics, a division of North American Aviation, Inc., associate prime contractor for Minuteman guidance and control system.

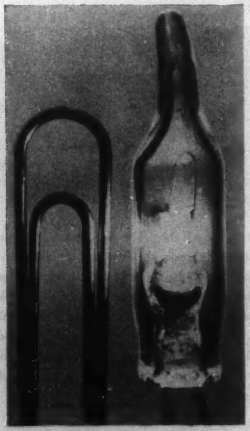


▲ Glass-enclosed precision film resistor with zero moisture absorption was put into mass production by Corning Electronic Components. It found use in miniaturized missile, computer, high frequency, radar, switching, and other circuits requiring exceptional performance.

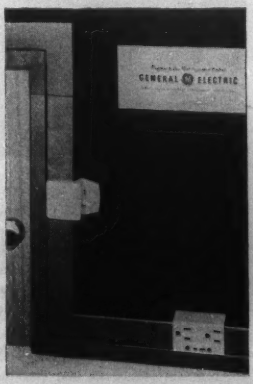
▼ Sylvania Lighting Products' new electronic indicator lamp has a life of 3,000 to 5,000 laboratory test hours, or an average of 10 times greater than the rated life of previous lamps. Flat-top end construction permits filament relocation, thus increasing end foot-candles, providing up to 60% more light. A plastic nylon cap eliminates the need for prismatic "jewels" or caps, which require separate mountings, and it may be either slipped or cemented in place.



▼ Remote reset circuit breaker with built-in indicator light was introduced by Sylvania Lighting Products. The device is designed for use in low-voltage electronic systems.



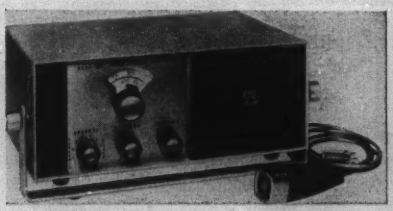
▼ General Electric Company's surface-mounted wiring raceway eliminates the need for in-the-wall wiring. The metallic raceway replaces baseboard or may be mounted over it. It screws directly to the surface of the wall and may be installed over doorways and around corners.



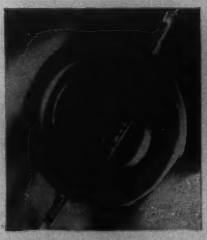
▲ Electronic circuits in trunk of specially equipped car pick up signals from road to operate vehicle automatically on full-size electronic highway installation at RCA's David Sarnoff Research Center. Experimental system uses highway circuits developed by RCA Laboratories and automatic car controls by GM Research Laboratories. Members of engineering staffs responsible for system are shown preparing to ride around test track with car under automatic control.

▲ Keeping an eye on traffic at busy Denver, Colo., intersection is a new infrared traffic detector (*top foreground*) introduced by the Minneapolis-Honeywell Regulator Company's Heiland Division. The Trafficol detector, according to Honeywell engineers, provides wide flexibility to traffic engineers in studying and controlling vehicular traffic. It can be mounted in a few minutes on a utility pole or on the side of a building and moved easily to a new location whenever traffic patterns change. The firm's engineers have said that the use of infrared-sensing techniques makes the device virtually foolproof for detecting and counting vehicles, even those traveling up to 80 mph.

▲ Electro Lane, a device to warn motorists when they are too close to pavement edge or centerline, is undergoing full-scale tests at General Motors Proving Ground. Developed by GM Research Laboratories, experimental device (*top*) is mounted over instrument panel in front of driver who can receive visible and/or audible warnings if car veers off electrical "path" of wire in pavement. Lower right photo shows ferrite core coils on front bumper which pick up electric signals from wire in center of lane. Lower left photo shows compact transistorized receiver package that goes in car (*left*) and oscillator unit which sends out low-frequency (2-kc) signals from road (*right*).



▲ RCA Mark VII Radio-Phone is an inexpensive 2-way radio operating in the newly assigned "citizens' band." It consists of a 5-watt 4-channel crystal-controlled transmitter and a highly selective and sensitive superheterodyne receiver, also crystal-controlled to four channels. Unit also incorporates a tunable receiver, permitting operator to switch from the fixed channels and tune into any of the 23 channels within the band.



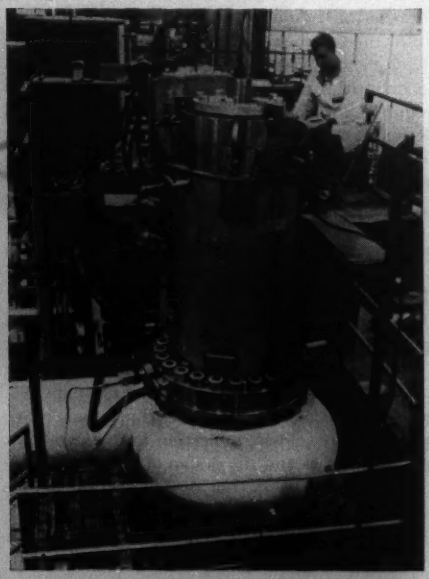
► General Electric 1-watt closed-space sealed-off unit has minimum power density of 0.2 watt per square centimeter of cathode surface as well as thermal efficiency of at least 2.5%. It is designed to operate at a cathode temperature of approximately 1,100 C.

▲ Project engineer Ray Reed stands in front of central control tower, developed by ITT Laboratories, Nutley, N. J., to monitor the operation of Project Turnkey, the first automated post office in the United States, recently completed in Providence, R. I.

▲ Deluxe control of home air conditioning is provided with Minneapolis-Honeywell "Weather Station" push-button panel. It contains all necessary dials and push buttons for controlling home's heating and air-conditioning system, plus indicators for indoor temperature and humidity, outdoor temperature, and barometric pressure, as well as an electric clock.

▼ A plastic cable sleeve installed temporarily over an unfinished joint or termination will keep dirt and moisture from the work overnight or for several days at a time if necessary. Announced recently by G&W Electric Specialty Company, the new sleeve will seal the exposed joint or termination against moisture and contaminants of all kinds to keep the work dry and clean.

▼ Shown under test at the Westinghouse atomic equipment department, this 1,600-hp canned motor pump is of type supplied for use at the Yankee Atomic Electric Company's power station at Rowe, Mass., and the Indian Point Power Station for Consolidated Edison Company. Pump circulates primary reactor water at 500 F and 2,000 psi by a centrifugal pump impeller attached to shaft of a squirrel-cage induction motor.



▲ Multiple mach–airspeed sensor was designed jointly by the Convair (San Diego) Division of General Dynamics Corporation and Aeromechanisms, of Van Nuys, Calif. It is used on the Convair 880 jet transport to provide mach–airspeed control and warning functions. Unit will accommodate up to eight plug-in switch modules, which are mechanically and electrically identical.

(Continued from page 1)

number comprised 52 of which 38 were vhf and 14 were uhf.

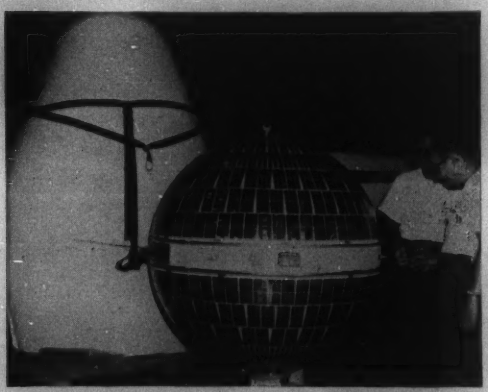
The Federal Communications Commission (FCC) continued to examine television allocation problems involved in utilization of vhf and uhf channels. They received authorization through Congressional appropriation for a $2 million study, to be undertaken with industry assistance, to explore uhf channel utilization in New York, N.Y.

After 3 years of consideration, the FCC finalized rules authorizing uhf stations to fill weak signal areas within their coverage contours by the use of up to 5,000-watts effective radiated power on channel booster stations. New provisions were made in the rules allowing 1-watt vhf translators.

In educational television, a "stratovision" project was initiated calling for broadcast equipment installation in two *DC-6* planes. Scheduled for take-off in February 1961 by the Midwest Council on Airborne TV Instruction, courses would be originated from a plane circling at 25,000 feet above central Indiana. A 2-year experimental operation utilizing uhf frequencies is envisioned.

Several methods of FM stereo broadcasting were field tested and a government-industry committee report was filed on October 28. Tests were conducted using special experimental facilities at KDKA-FM, Pittsburgh, Pa. The National Stereo Radio Committee presented quantitative information and test results from a number of systems most of which would permit simultaneous use of other multiplex channels for functional music or other services.

Broadcast engineers continued to work toward increased mechanization and automation in audio and video programming techniques. Audio-tape and film cartridge packaging received extensive attention. Automatic program logging and packaged tape programming developments were described to the industry at several technical conferences.



A 500-pound Courier satellite stands beside the nose fairing of a Thor-Able missile. Courier satellite system was established October 4, 1960, by the U. S. Army Signal Research and Development Laboratory. Approximately 20,000 solar cells provide for the power supply. Information storage capacity is 16.5-million bits with a data access rate of 55 kilobits per second. Satellite space station was designed and built by the Philco Corporation.

COMMUNICATION SWITCHING SYSTEMS

A MOST PROMINENT EVENT occurred in telecommunication switching in 1960 when the Bell System opened for public use its experimental electronic switching system at Morris, Ill. Exploratory efforts in electronic switching are continuing in many research laboratories throughout the world. Several electronic PBX's and small exchanges have been put into experimental use.

Expansion of nation-wide direct distance dialing (DDD) increased rapidly, including in-dialing to stations of several commercial and government PBX's. Operator distance dialing is now possible to Alaska, Hawaii, and Puerto Rico. To facilitate future expansion of nation-wide dialing, telephone numbers are being converted from the combination of letters and numbers to all number calling (ANC). In 1960, many telephone numbers were converted to this new form which should spread rapidly during the next decade.

Customer dialing of person-to-person and other premium charge calls has started in several locations. An operator is brought into the telephone connection to assist the calling party in reaching the particular person desired, after which she starts the charging on the call. Also, the operators perform other special services for the calling party, such as securing acceptance of charges on collect calls, transferring charges to a third telephone, etc.

A variety of remote line concentrators have been introduced commercially in a number of applications in the United States to defer the need for new exchange area distribution cables and to meet special plant needs.

Application of digital computers has been much in evidence in the telephone industry. The manufacturers and telephone companies are using computers to determine quantities and other specifications of equipment required for complex switching system installations. Research and development laboratories also use computers in the design and simulation of switching systems.

COMMUNICATION THEORY

IN THE CONTINUING RESEARCH on noise and continuous systems, matched filters played a prominent part, both as the basis for new systems, and also as the subject of a number of theoretical studies.[1] Increasing emphasis is being placed on the design of signals with a view to coping most efficiently not only with Gaussian but also with impulsive forms of noise.[2] In this area, a paper reporting a new class of codes for noisy continuous channels may foreshadow closer connection in the future between coding theories and the design of signals.[3]

New fundamental work on the theory of binary group codes has appeared during the past year, lead-

ing to methods of constructing new error-correcting and error-detecting codes superior to any previously known. The Bose-Chaudhuri codes, a generalization of Hamming codes, correct random multiple errors.[4-5] A number of papers have discussed new codes for correcting bursts of errors. [6-11] All these codes can be implemented efficiently and most of them generalized to handle nonbinary information.[12] Several test models of encoding and error-correcting equipment have been built.[13-14] New work on feedback systems has also appeared.[14-16]

On a whole, the year saw an increased emphasis on the changing properties of transmission media, and various means, coding or otherwise, for compensating for changes.[13-14] The climax of last year's work was the all-day session on data transmission at the AIEE-NEC (National Electronics Conference) joint meeting.[14] This session featured a stimulating interchange of ideas between the theorists in coding and signal design and the engineers specializing in data-transmission systems and channels.

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DATA COMMUNICATION

In 1960, outstanding progress in data communications was made in the utilization of voice-grade facilities. A flexible data-transmission system was announced which is capable of transmitting 5-, 6-, 7-, or 8-hole paper tape with automatic error control at speeds ranging from approximately 10 characters per second up to 100 characters per second. A magnetic tape transmission system operating at 1,200 bits per second over regular telephone facilities was developed; also, a system which permits a data processor to communicate with a similar computer or with a magnetic tape unit. A new punched card to magnetic tape transmission system was announced, operating with 3-level AM vestigial sideband modulation at 2,400 bits per second over specially equalized lines.

Parametric converters have been applied to the receivers of the AN/FRC-47 tropospheric scatter communication system in order to achieve an improved system signal-to-noise ratio. Developed by GE, this equipment converts a signal in the region of 350 to 450 mc to 10 kmc and then to an i-f frequency of 16 mc. A drift cancelled loop is utilized to minimize the undesired effects of pump frequency variations.

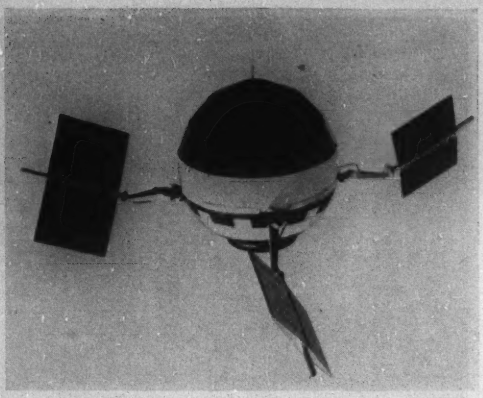
Comprehensive high-speed reservation systems have been adapted for two airlines. These will use data communications to link their principal offices across the country with a central computer. Information was published on the transmission capabilities of the regular telephone network for data transmission. A very high-speed magnetic tape transmission system was introduced, operating over leased channels at a speed of over 100,000 bits per second. Data transmission to and from satellites was used for control and monitoring purposes and unquestionably involved the longest distance applications.

Considerable progress was made in the realm of error detecting and correcting methods and applying these economically to data-transmission systems. It appears that we are on the brink of a period which will witness widespread applications of recently developed electronic data-transmission methods.

RADIO COMMUNICATION SYSTEMS

Progress in long-range communication systems continues at an accelerated pace, and the achievements of this past year portend even greater accomplishments for the very near future. Highlights of this recent progress include longer range tropospheric scatter and space satellite systems.

A great stride was taken in 1960 in increasing the distance of a single hop of tropospheric scatter communication when the U.S. Air Force placed in service its 690-mile *AN/FRC-47* equipment linking Thule, Greenland, and the continent of North America. This is a 24-channel single-sideband (ssb) system featuring



This is a view of the space borne elements of the Pioneer V satellite with which communications were maintained up to a distance of 22½ million miles from the earth.

quadruple diversity and high radiated power to achieve great reliability of communicaton. Complementary to this development, a new thin-route tropospheric scatter system was also demonstrated that features low cost and transportability.

The first space satellite communication systems were placed in orbit and evaluated in 1960. These include the passive repeater satellite Echo, and the active repeater, Courier. The Echo satellite was placed in orbit on August 12, 1960, and signals, including a message from the President of the United States, were successfully communicated over great distances that same day. The Courier satellite was placed in orbit on October 4, 1960, and has been used to record and repeat teletypewriter messages carried around the world. The earth's natural satellite, the moon, also was used as a passive communication repeater in experiments by the Navy. These tests include the transmission of facsimile signals from Hawaii to Washington, D. C.

Of considerable importance to the success of these achievements in long-range communication systems has been the application of new developments in solid-state components. The receivers of the *AN/FRC-47* tropo-scatter system have been equipped with parametric amplifiers and the resulting improvement in receiver noise figure has given a 3-db improvement in the system signal-to-noise ratio. Similar results were also demonstrated through the application of this same type of amplifier on the moon-bounce communication tests.

A ruby maser amplifier, refrigerated by liquid helium, was used in the Bell Telephone Laboratory equipment employed for passive space satellite communication tests in connection with the Echo satellite.

Another important milestone for the year was the production of all-transistor high-quality 600-channel ssb telephone carrier multiplex equipment for cable and microwave relay applications. This system is compatible with International Consultative Committee on Telephone and Telegraph (CCITT) recommendations and Western Electric Company practices. The system, including signaling units, contains no vacuum tubes or relays.

SPACE COMMUNICATION

THERE HAVE BEEN several very important developments in space communication during the past year. The National Aeronautics and Space Administration (NASA) placed a 100-foot diameter metallized plastic balloon in orbit about 1,000 miles above the surface of the earth on August 12, 1960. On the same day radio signals reflected from this balloon were used for voice transmission between the Bell Telephone Laboratories installation at Holmdel, N. J., and NASA's Jet Propulsion Laboratory at Goldstone, Calif. The experiment, known as Project Echo, employed several techniques to provide a very low noise receiving system consisting of a low noise horn reflector antenna, a broad-band maser amplifier using a ruby crystal refrigerated by liquid helium and a receiver using a feedback technique for recovering an FM signal which would ordinarily be lost in the noise. The received noise is essentially that generated by the warm atmosphere and by extra-terrestrial sources. The combination of antenna and maser provide a background noise power about 1/100 of that encountered in ordinary microwave radio systems.

Communication with the Pioneer V satellite which was launched by NASA on March 11, 1960, was maintained for 3½ months during which the space probe reached a distance of 22.5 million miles on its way into orbit around the sun. The integrated telemetry, tracking, and ground system of Pioneer V would have operated out to distances of nearly 100 million miles had there been no degradation of battery capacity in the payload. Approximately 3 million binary-coded bits of information were telemetered during this time at rates from 64 to 1 pulse per second. The transmitter could be operated with either normal power of 5 watts or, on ground command, with an amplified power of 150 watts. The ground receivers employed 60-foot and 250-foot parabolic antennas with parametric preamplifiers.

The Tiros I weather television satellite was launched April 1, 1960, and the Courier I communication satellite was launched October 4, 1960. The latter with its two ground stations is a delayed repeater satellite communications system capable of voice, facsimile, and high-speed digital transmission.

TELEGRAPH SYSTEMS

THE PAST YEAR has brought about many new developments in the "line-switching" of teletypewriter communications—the direct connection of the originating and terminating station, as contrasted to "message switching" in which each message is relayed from switching center to switching center on a store-and-forward basis. The ability of the present telephone switching networks to connect rapidly any point on the network to any point on the network, coupled with

more economical transmission facilities, has accelerated the developments in line-switching.

The Western Union TELEX system, an example of a line-switching network wherein a subscriber may dial a distant station directly, is presently being expanded to approximately 25 cities. It was announced that the Telephone Companies' TWX network, presently permitting direct point-to-point connection (line-switching) through operators, will be converted to completely automatic dial operation, permitting the direct connection of TWX stations in a manner similar to DDD between telephone subscribers. Other line-switching applications such as teleticketing (the transmission of tickets) have recently been placed in service.

Message switching systems still find new applications, especially where there are multiple-address and broadcast requirements. A recent development is the Automatic Data Interchange System (ADIS) developed for the Federal Aviation Agency (FAA) which will enable the FAA to increase greatly the speed and scope of its weather communications service, collecting meteorological observations from some 600 stations and distributing them to 2,400 points of use.

ADIS is an electronic message switching system. A backbone circuit, operating at 850 wpm, is used to interconnect 15 100-wpm area circuits. Weather data gathered from each of the area circuits will be broadcasted on the backbone circuit for selective redistribution among the other area circuits throughout the country. The low- and high-speed circuits "talk" to each other by means of electromechanical tape readers and reperforators arranged as speed converters. Solid-state and relay logic elements sequentially call originating stations, classify messages by priority, select only those weather items wanted at the receiving stations, and deliver them to the area circuits.

WIRE COMMUNICATION

DATA TRANSMISSION, over more or less conventional telephone circuits, attracted much attention during 1960. The handling of "data" or "machine language," in addition to or even entirely in lieu of the spoken word, using some form of voice-frequency carrier-telegraph is not new but the recent interest in this area can be appreciated from the fact that there were at least 12 AIEE papers presented in 1960 which, in some one or more ways, touched on the transmission aspects alone.

Interest in transmitting machine language is not confined to the United States as evidenced by the fact that there were symposia held in Canada during the last year dealing with the technical aspects of and the transmission problems involved in data handling. Of course, in Europe, a parallel interest has manifested itself and has been actively studied by the CCITT.

Some of the technical coverage given this type of data transmission can be visualized by merely reviewing the titles of the AIEE papers referred to earlier. Among them can be found: (1) "The Effect of Delay Distortion on Data Transmission"; (2) "A Delay Distortion Simulating Set"; (3) "Layout and Adjustment of a Nationwide Facsimile Network"; (4) "Evaluating the Telephone Messase Plant for Data Transmission—Description of Testing Program"; (5) "Basic Transmission Characteristics of the Telephone Network—Net Loss, Bandwidth, Delay and Noise"; (6) "Data Transmission Performance of the Telephone Network—Error Rates, Error Distributions and Error Control"; (7) "Survey of Cable Characteristics for Data Communciation"; (8) "Wire Line and Carrier Communications on the Union Pacific Railroad"; (9) "Precision Envelope Delay Measurements at Audio Frequencies"; (10) "Data System Tests Using Simulated Transmission Impairments." Other publications and periodicals also dealt at some length with the equipment and mechanical aspects.

The great interest in data transmission is closely related to the tremendous upsurge in computer technology, automation of processes, automation and centralization of inventory control, payroll handling, decentralization of industry, etc., and can be expected to increase further at a phenomenal rate. Apparatus which was specifically designed for use in data transmission, such as "Datacom" and "Dataphone" were described in earlier publications and it now appears that these will find substantial application in the "mechanization" of TWX service.

General Applications

AERO-SPACE TRANSPORTATION

MANY DEVELOPMENTS applicable to the aero-space field were reported during the Aero-Space Transportation Conference which convened at San Diego in August in conjunction with the AIEE Pacific General

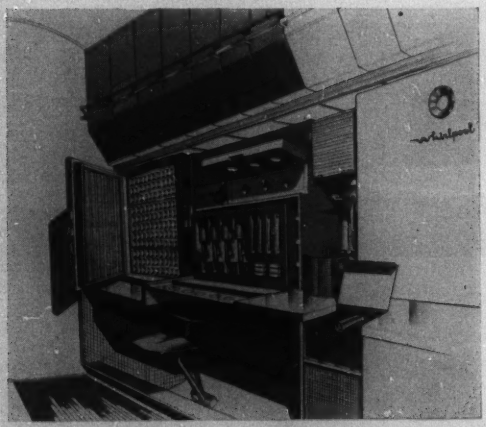
A new remote-control room air conditioner by Whirlpool Corporation uses a saturable core reactor to get stepless control of the air circulating fan. A thermostat is in the remote control box placing the temperature control point right at the user's side.

Interior view of the ground station control van developed by the ITT Laboratories for the Courier I satellite project.

Meeting. The July issue of *Electrical Engineering* published the techical program. Representative topics included:

1. *Space Systems and Design Problems Peculiar to Space Environment.* Objectives and capabilities of photovoltaic energy converters, configuration effects on solar photovoltaic systems for earth satellites, selectively emissive materials for solar heat absorbers, the evolution and testing of a navigational satellite, and sensitive circuit control for missiles and space vehicles were discussed.

2. *Thermionic Converters and Magnetohydrodynamics.* Papers were presented varying from basic concepts of converter design to general problems concerning the application of thermionic converters to space vehicles.



A Whirlpool Corporation space kitchen to serve three men being built under contract for the Wright Air Development Division, ARDC, U. S. Air Force. Seven and one-half feet in diameter and less than 10 feet long, it will contain food and beverage storage area, a thermoelectrically powered miniature refrigerator and freezer, oven, a 2½-gallon hot water system and food waste storage facilities.

3. *Cryogenics.* The temperature region from —196 C to absolute zero has come to be associated with rockets, many of which carry large quantities of liquefied hydrogen and oxygen propellants. Potential applications of cryogenics to future aero-space electrical and electronic designs were presented.

4. *Environmental Problems.* Included in this category were progress made in designing electric components to withstand nuclear radiation and high-temperature, the performance of electrical connectors at pressures equivalent to 300,000-feet altitude along with a design concept to solve the problems, and the developments on 600 F electric systems.

5. *Miscellaneous.* Other significant developments reported at the Aero-Space Transportation Conference included analog computer representation of aircraft power systems, practical applications of thermoelectricity, methods for defining limits for voltage transients, and the accomplishment of variable-speed constant-frequency aircraft electric generating systems.

A relatively new building block approach to ground operational communications called the NORCOM has been reported. From 2 to 50 or more operators can be grouped on a single 2-wire conference line with negligible degradation of the signal level. The individual stations are about 9,000 ohms, whereas the line is arbitrarily loaded to about 300 ohms. Thus, the variation in the number of operators has little effect on the line loading and signal level of the line. This concept appears to be a break-through in ground communication for applicabliity to missile-space support systems.

DOMESTIC AND COMMERCIAL APPLICATIONS

THERE WAS A STRENGTHENING TREND in 1960 toward engineering domestic appliances in depth, based on new research and analysis of human needs. This stems from studying the forms in which energy is available and how to translate its use into satisfying the consumer demand for economical products which raise the standards of nutrition, sanitation, general cleanliness, and convenience.

The appliance industry has been noteworthy in its ability to maintain equal or better values in appliances at about the same dollar level during the past 20 years, in spite of inflationary factors, through integrating technological improvements from many fields into appliances and their manufacture. Recent examples are computer programming to purchasing and manufacturing functions and the use of gas-filled foam insulation to reduce wall thicknesses in food storage appliances.

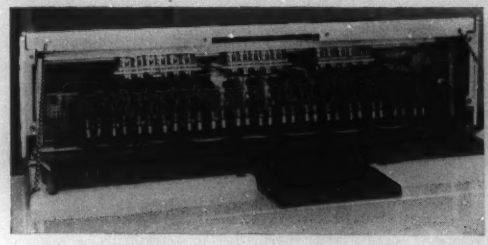
New concepts are being explored to improve reliability of appliances. Solid-state switching modules, transistor amplifiers, and electronic timing devices have been combined experimentally into a programming control for an automatic washer. The Peltier effect is being engineered into devices to pump heat in the environmental conditioning of people and food.

In the field of commercial food preparation the trial of uhf energy for domestic cooking has been re-examined and found to be well suited for reheating previ-

ously prepared and frozen food portions. The speed and convenience possible through the new techniques permits the serving of exotic dishes prepared by famous chefs in the home. This development is on trial in a kitchenless restaurant in Chicago and also in a large company cafeteria. This development is expected to reflect back into the home appliance field with far-reaching results.

The trend toward coin-operated appliances grouped in a central location to obtain economically a variety of domestic services is growing into a world-wide movement, as well as spreading out this year to include coin-operated dry-cleaning appliances.

The tremendous speed with which engineering is moving in the appliance field is accented by the challenge of space and effects of zero gravity in the kitchen. This challenge to the industry, laid down by the Wright Air Development Division of the ARDC, U.S. Air Force, is how to supply three space pilots with the food and beverages they would require in a future mission in outer space. The appliance engineer will need to draw upon all facets of the engineering profession to meet this challenge and, in turn, plow the knowledge gained back into consumer products.



P. R. Mallory and Company, Inc., are exploring the future application of solid-state timing and switching modules to appliance circuitry as demonstrated by this experimental solid-state program control for washers of the future. Instant programming changes and elimination of mechanically operated contacts are potential advantages.

LAND TRANSPORTATION

THE RAILROAD and transit industries continued their advances toward higher standards of transportation performance. The increasing capabilities of electric propulsion equipment reflects this progress.

The Pennsylvania Railroad received the first of 66 rectifier locomotives with a continuous rating of 4,400 rail hp. These *C-C* 11,000-volt 25-cycle locomotives will replace 92 freight locomotives which entered service between 1931 and 1935.

Higher speeds and lower over-all maintenance costs demand more horsepower in prime-mover-electric locomotives. Domestic designs of diesel-electric locomotive show this trend, with a *B-B* locomotive rated 2,500 hp to the generator for traction announced during the year.

Four 100-hp motors power rapid-transit cars which entered service in Philadelphia. Advanced structural techniques and high power-to-weight ratio in electric propulsion equipment contributed to a light weight of 51,500 pounds. Scheduled to operate at 45 mph in Philadelphia, these cars are capable of attaining speeds in excess of 70 mph.

Engineering studies revealed that new rapid transit systems in the 1960's will demand continuing advances in horsepower-to-weight ratios of rolling stock. Operating speeds will reach 80 mph. The extensive application of automation techniques will aid in the achievement of optimum system performance and safety. Trial operation of new design trucks and of an automatically controlled train during 1960 demonstrated progress of importance to future and to existing systems.

Revolutionary developments are occurring in component areas. New materials and continuing research are making possible significant advances in insulation

Stainless steel cars on Philadelphia's subway-elevated line are designed to accelerate at the rate of 2.75 miles per hour per second, cutting 6 minutes off the running time on the 12.8-mile 28-station line.

Mainline 6-axle, 195-ton, rectifier locomotive rated 4,400 hp, for service on the 11,000-volt 25-cycle electrification for the Pennsylvania Railroad.

View of a 3-car automated train that has been undergoing tests for about a year on the tracks of the Sea Beach Line of the BMT Division of the New York City transit system.

systems for traction equipment. Transistors, semiconductor diodes, and controlled rectifiers are promising new simplicity and standards of performance for electric propulsion equipment.

Current technical achievements in Europe in railroad electrification and automation are notable, and are receiving important attention in this country.

PRODUCTION AND APPLICATION OF LIGHT

THE PAST YEAR has witnessed continued recognition by lighting users of the need for higher lighting levels in all areas of application. Many significant developments in light sources, luminaires, and auxiliary equipment have aided this acceptance.

A new concept of electrical space conditioning has developed this year, along with the trend to higher lighting levels. Through electrical space conditions, lighting can not only provide seeing conditions, but it can provide a major portion of the heating requirements as well. It also permits incorporation of lighting with heating and cooling for the greatest value in total building systems. Several new air-handling troffers have been introduced which permit close integration of lighting and cooling systems.

Several significant developments in light sources were announced during the past year. The oxide-coated electrode, mercury-lamp design has been extended to sizes from 100 through 1,000 watts. This design provides greatly improved maintenance of light output throughout life, as well as easier starting requirements at low temperatures.

New fluorescent developments include an aperture lamp with a 30 degree "window," several special-length *T-8* lamps for appliance and vending machine applications, and a greenish-white color with high efficiency.

Flexible plastic electroluminescent lamps are now available in four colors for specialized low brightness applications.

Quartz infrared lamps are now available for any vertical burning position. A new 1,000-watt bend-end quartz infrared lamp has been developed to permit location of the lamp seals away from the hot zone.

Two new significant developments in fluorescent ballasts have been announced this past year. A new solid-fill fluorescent ballast design has been developed in which the case, coil, and core are reported to be permanently bonded into a single unit which cannot leak. Also a new weatherproof ballast has been announced with a molded plastic case which permits mounting in any position.

Industry

CHEMICAL INDUSTRY

AMONG THE MANY DEVELOPMENTS in power sources the fuel cell perhaps has been given the most concentrated effort, both here and abroad. It has been well publicized and many working laboratory models have been successfully displayed.

Fuel cells are devices which produce electric power from a fuel and oxydizer which are fed into the cell as electric power is withdrawn. This process has the useful property of being twice as efficient as the best of any other method of converting the energy of the fuel to electric energy. The concept is old but previously there had been no practical cell available for any application.

Most cells have used compressed oxygen and hydrogen, but the bulk and weight, particularly of the gas cylinders, are marked disadvantages. An improved cell has been demonstrated, which uses air as an oxydizer and obtains hydrogen by the reaction of lithium hydride and sulfuric acid. This cell is compact, shows more power per given weight than storage batteries, and is utilized in some military applications. The fuel cost for this cell is relatively high.

Other types of fuel cells are being studied and although interesting progress is being made, the solution to many difficulties, such as life, cost, size, and fuel supply, remain to be solved; no cells are immediately available for commercial utilization. Hydrogen and some finely divided metals appear to be the only fuel which react efficiently at room temperature, while cells capable of using other fuels operate at high temperatures and pressures and are lower in efficiency with limited life.

While there appears to be no immediate solution to these many problems, enough effort and funds are being expended so that eventually a practical fuel cell should be developed.

The semiconductor power rectifier and, particularly, the silicon rectifier, has become accepted as the principal conversion means in the electrochemical industry, not only in low-voltage applications but also for the higher voltages used in that industry. This acceptance extends all over the world and is due to the steady improvement of the rectifier cells and the consequent reliability of the conversion equipment.

As far as new installations in the electrochemical field are concerned, the semiconductor rectifier has largely replaced all other means of converting a-c to

d-c not only in view of the continuity of service obtainable but also due to the high efficiency and the relatively low price of this type of rectifier.

ELECTRIC HEATING

THE YEAR 1960 saw a wide variety of new developments in industrial electric heating. Some of them are as follows:

A consumable electrode vacuum melting furnace at Midvale-Heppenstall, Philadelphia, Pa., turns out ingots 5 feet in diameter.

Quartz infrared lamps, normally designed only for horizontal operation, are now available for vertical operation. Quartz lamps have also been developed having terminals offset 90 degrees from the lamp axis for use in high-temperature applications.

A new electric furnace for continuous bright annealing of stainless steel strip, developed by General Electric Company of Shelbyville, Ind., has made it economical to substitute bright annealing for conventional anneal and pickel operations in normal steel mill production, and has had a heavy impact on the stainless steel industry.

A 6,000-kva ore car facility is being installed by Radcor, Inc. at the Chicago Northwestern Escanaba Docks in Wisconsin. It is 276 feet long using quartz infrared lamps on the sides and metal sheath heaters underneath, and is capable of thawing ten 70-ton ore cars at a time.

The New Rochelle Thermatool Corporation has extended its high-frequency resistance welding process to include high-speed welding of fins to tubing for such applications as heat exchangers.

A new method of heating dense rapidly flowing gas at pressures up to 13,000 psi and temperatures up to 1,500 F employs direct contact between the gas and the live resistor surfaces.

Two electric steam boilers at "Rancho Quien Sabe" process feed for prime beef steers. They provide fast availability of live drying steam, ease of control, and reduction of fire hazard in the hazardous atmosphere.

Three 2,500-watt 480-volt high-intensity tubular quartz lamps backed by an aluminum reflector are used to flash-heat carbon paper forms as they are threaded past the lamps to float a microfilm of pure wax to the surface of the carbon and eliminate smudging, at the Sacramento News Publishing Co., Sacramento, Calif.

High-intensity radiant heating is also employed in a 300-kw continuous furnace for aluminum brazing of fry pans, griddles, and sauce pans at the Sunbeam Corporation in Chicago, Ill., and provides the close temperature control demanded by such an operation.

FEEDBACK CONTROL SYSTEMS

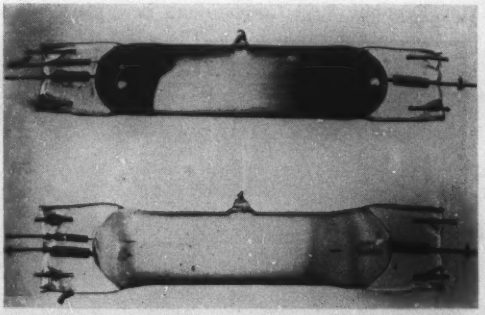
THE 1960 HIGHLIGHT in the automatic control field occurred mid-year with the tremendous interchange of technical information at the first Congress of the International Federation of Automatic Control (IFAC) in Moscow, USSR 1960. The world-wide interest in automatic control was emphasized by the presence of scientists, engineers, and executives from 20 countries. More than the average interest was shown in the areas of adaptive systems, optimum systems, and numerical methods for the control of machine tools. International attention to automatic control was again brought to mind by the October 1960 congress and exhibition for Instrumentation and Control at Dusseldorf, Germany. Efforts will be made for a greater emphasis on applications of control theory at the second IFAC Congress in Switzerland, 1963.

Feedback control, which has continually expanded its horizon from components, to systems and to processes, was extended to include management functions at the Joint Automatic Control Conference (JACC), Massachusetts Institute of Technology, September 1960, in a paper by R. B. Wilcox titled "The Application of Feedback Control Techniques to Organizational Systems."

There is no doubt that national security continues to require a withholding of any disclosure of many challenging developments and applications of feedback control in the probing of outer space and in the applications of nuclear devices.

Evidence from the National Machine Tool Exposition in Chicago showed a general industry support by the machine tool builders for integrating numerical tape controls into their products. This applies to all types of machine tools, such as lathes, milling machines, borers, multiple tool machines, presses, and many specialty machines.

The gap between control theory and its application in the process industries continued to decrease as the number of installations increased. Control theory applicable to processes with multiple controllable and uncontrollable variables is being applied. Typical applications in the chemical industry are the successful full-time control of the Monsanto ammonia plant, Luling, La., and a B. F. Goodyear Chemical Co. plant in Calvert City, Ky., both with *RW-300* digital computing control systems. In the steel industry where many of the major control problems were previously



Mercury lamps with oxide-coated electrodes are now available in 100- through 1,000-watt types. Mercury lamp arc tubes shown have been burned for 8,000 hours. (Above, old design; below, new oxide coated electrode design.)

Courtesy Westinghouse

Prodac Tin Line Data Processing Input Cabinet.

understood only by the industry, there has been a successful joining of the user, process designer, and automatic control designer, to produce and install automatic control equipment in a hot-strip mill. A Daystrom information system will be integrated into the mill being built for the Great Lakes Division, National Steel Corporation, by the United Engineering and Foundry Company. It is expected that adding this computer control will increase the mill output by 100%. There is no doubt that the application of feedback controls to provide an integration of automatic control into plants associated with the chemical, oil-refining and steel industries will continue at least for several years to come.

INDUSTRIAL CONTROL

Automatic Plate Mill Control. The electrical controls for Republic Steel Corporation's new plate mill at Gadsden, Ala., are more advanced than any previously applied on a steel rolling mill.

View of control room for steel-strip and coil-welding line.

The complete mill, from slab furnace to runout tables, is controlled by an industrial in-line computer, and the variable voltage drive controls themselves have transistorized static switching instead of conventional sequencing relays.

The variable voltage auxiliary generators are excited directly from 400-cycle magnetic amplifiers and employ an "on-off" type regulator for optimum response characteristics.

In addition to controlling the sequence of mill operations with two slabs in work simultaneously, the computer will control the finished width and thickness of the steel plate.

Static Control for Electric Shovels. The long sought after static shovel control which requires no rotating regulators or exciters for generator field excitation has been made possible for loader size shovels by the advent of the high-gain high-power Trinistor-controlled rectifiers.

The regulator stage (brain or computer) which controls the Trinistor generator field exciter can now be supplied as small, low-power, standard, replaceable packages enabling a uniformity and reliability which will eliminate many of the major maintenance problems.

Pulsetter Paper Machine Drive. A pulse-digital-type speed regulator is controlling a sectional paper machine with greater accuracies than any other drive system. A pulse signal proportional to actual section speed is compared, pulse for pulse, to a reference pulse train. The transistor static switches operating in an "off-on" mode are not susceptible to the varitions in gain, temperature, or drift of the analog type of speed feedback system. Accuracies of 0.025% are obtainable where systems using voltage generating tachometer and voltage references are limited to a minimum error of 0.1%.

Control Room for Steel Strip and Coil Welding Line. All electrical controls for a complete coil-welding line in a major steel mill are enclosed in a factory-assembled room ready for installation. Completely prewired and interconnected, the package eliminates 4 to 5 weeks installation time normally required.

The control for 17 motors in all features three large d-c drives with silicon-controlled rectifier field regulators controlling unwind, tension, and rewind. Transistorized static acceleration and deceleration circuits provide smooth speed control for the line. Unique photoelectric loop control provides a continuous output proportional to loop depth.

INDUSTRIAL AND COMMERCIAL POWER SYSTEMS

COMPREHENSIVE DOCUMENTATION was developed in 1960 for preferred system voltage nomenclature for industrial plants and commercial buildings. The documentation takes account of favorable zone and tolerable zone voltages at the point of utilization equipment, at distribution transformers, and at substations at subtransmission or transmission levels. It systematizes

the many voltage designations in prior use and is being recommended for use in future AIEE publications and by the American Standards Association (ASA).

Voltages have been given fresh attention from another point of view—high-frequency. High-frequency voltages have been spurred by high-frequency fluorescent lighting. Frequencies up to 1,000 cps have been reported upon, with only minor peculiarities and limitations in system design being cited. Conservative designs using 60-cps techniques are felt to be quite satisfactory.

Progress has been reported with 400-cps 1,000-volt systems for airport apron lighting to the extent that standards are urged in some quarters. The need is based upon increasing demand by aircraft that will be served. Supersonic commercial aircraft, when a reality, will increase the demand further.

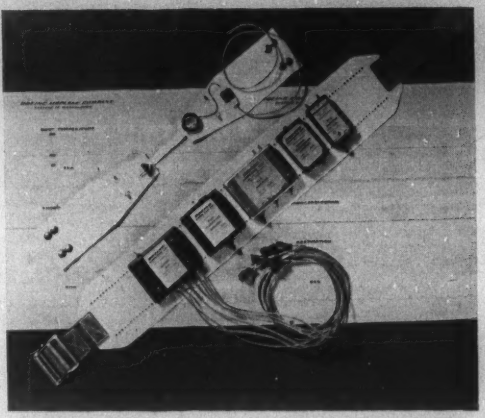
Digital computers with automatic programming techniques look promising for industrial power systems design studies. Even though the cost of developing digital computer programs may be high, especially because industrial design problems are not repetitive, there are many applicable programs available that have been developed for electric utilities. Two classes of such programs are (1) those for circuit analysis and (2) those for system optimization. With such utility programming available for industrial systems studies, executive and exacting studies become possible that would be difficult with hand calculation or analog devices.

Another step forward in system design is the increasing use of present worth and probabilities to assign dollar values to such intangibles as safety, reliability, and voltage quality. This concept leads to the concept of true system cost—namely, the initial cost of the equipment plus the present worth of all costs that will be caused by imperfections in the system during its lifetime.

METAL INDUSTRY

Of many significant advances that have been made in the application of electric systems to metal industry drives for rolling mills and processing lines, the most significant is the application of digital forms of transistorized automatic controls. Such forms of equipment are used for card programming controls, on-line computer controls, and data-accumulation systems. Card programming controls have been extensively applied on primary rolling mills, many of which are in service in the steel and nonferrous metals industries. Such forms of control offer the user a means of achieving high production of quality product. All decisions relating to the operation of the process are predetermined and scheduled and introduced into the control by means of punched cards.

At present, on-line computer controls are being applied to rolling mills and processing lines, and are characterized by the need for a minimal amount of input information and significant degrees of feedback signals from the process itself. The role of the computer is that of calculating the best mill or processing line operating procedures and initiating intelligence to the electric control systems associated with the various drives such that computed operation conditions are achieved.



A respiration transducer and some of the amplifiers used for monitoring and telemetering the condition of man and his response to space conditions.

The use of data-accumulation systems in conjunction with computer controls or standing by themselves for the purpose of providing management and operation information, continues to grow in the steel industry. Such systems are being applied to processing lines as well as rolling mills.

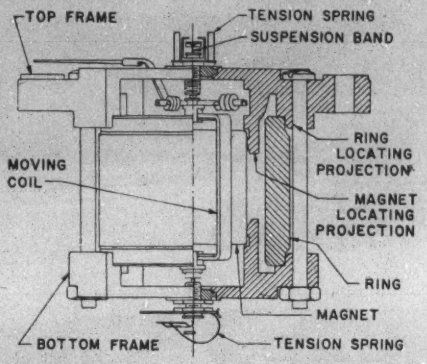
The form of equipment used for card programming controls, on-line computer controls, and data-accumulation systems is generally of the all-static, highly transistorized form.

All-static Prodac data-processing controls have been supplied for use on electrolytic tin plate lines. The line footage signals for strip speeds up to 2,000 feet per minute (fpm) are obtained from Rotrac pulse tachometers and each control contains counters for total coil feet, total prime feet, and the total footage of each of 13 defect footages. Any foot of strip containing one or more defects is excluded from the prime footage total. The coil identification information is set into the control by either a punched card or by selector switches. All this data is punched on tape which then operates a printer to produce a coil ticket and is also later used to produce a punched card record.

PETROLEUM INDUSTRY

THE MOST PROMINENT recent engineering developments in the petroleum industry involve the protection of motors and the expanded use of automatic control equipment.

There has been significant increase in the application of economical drip-proof and NEMA (National Electrical Manufacturers Association) type *I* weather-protected motors with "sealed" insulation systems in outdoor petroleum installations. One major refining



Taut band suspension bearing core-magnet moving-coil switchboard instrument mechanism. One of three types of mechanisms announced in 1960 which make all electrical measurements for switchboard instruments possible with the advantages of taut band suspension. This eliminates bearing wear and provides increased sensitivity with practical immunity to friction errors and effects of vibration and shock.

company has reported satisfactory operation of more than 20 such motors having silicone-rubber insulated form-wound coils. Continuing improvements in the insulation of both random-wound and form-wound coils is expected to accelerate the trend away from totally enclosed motors in petroleum service.

The development and testing of positive-temperature-coefficient thermistors for direct sensing of winding temperature in oilfield pumping motors has enhanced the accuracy of overload protection in the 2- to 30-hp range. Service tests conducted on a representative group of oil-field motors have emphasized the inadequacy of many conventional relays to protect machines from overload damage or to prevent nuisance tripping under a variety of field conditions.

Much work has been done in the automatic and remote control of trunk liquid and gas pipeline systems. This trend has spread to such diverse areas as crude oil lease pumping systems and high-speed aircraft fuel loading systems. Because of the increasingly heavy traffic at modern airports, the large fuel requirements of jet aircraft, and the need to minimize fuel loading time, automatic, fixed, highly reliable, high-capacity fuel loading systems have been designed for installation at many commercial air fields. The control equipment incorporated in these systems accommodates five or six different types of fuels, flow rates ranging from 50 to 1,200 gallons per minute per aircraft, and the possibility that one or more of the many pumps required may be out of service.

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TEXTILE INDUSTRY

TWO SIGNIFICANT electrical developments have been completed by an electrical engineering development group working within the textile industry. An automatic quill inspection and sorting machine was developed to detect and cull bent or warped quills at high speed. While quills are subject to inspection after manufacture, and only good quills shipped to the user, those quills that warp or become bent or out of round in service may cause undesired yarn tension variations or reduced size of yarn package. Runout of the quill is detected photoelectrically while the quill is rotated in a beam of light. A detection circuit sensitive to peak variations in runout above preset limits causes a rejection gate to operate and separate the bad quills from the good. The quill checker is useful in removing defective quills from production, evaluating new quills obtained from different sources, and in studying quill performance over long periods.

A second development is a high-density photocell array. While the development is expected to be useful in several fields, it was first applied for programming the pattern produced by a carpet tufting machine. To program a nonrepeating pattern on a 15- by 20-foot carpet without a pattern control cylinder of excessive size and cost, a photographic film is used. The film, capable of very dense information packing, is prepared from a designer's sketch with light and dark areas corresponding to portions of the carpets having high or low pile. Light and dark areas of the film are detected by the high-density linear photoconductive cell array in which the spacing of adjacent cell elements is 32 per inch. Each cell array may contain as many as 90 individual cell elements. Scanning the film as tufting proceeds, the control senses which areas of the pattern require high or low pile and control the operation of the individual tufting needles accordingly.

Instrumentation

AERO-SPACE INSTRUMENTATION

INSTRUMENTATION of flying vehicles has come a long way from the "seat-of-the-pants" flight testing of not-so-many years ago to the sophisticated tape systems and electronic-brain analysis of test data in use today.

At the 1960 National Telemetering Conference, produced through co-operation among five of our national technical societies, we heard about such things as television systems for control, supervision, and return of information in a soft landing of a vehicle on the moon. Eighty channels of real-time data will be examined, even though the vehicle is in range of a given station for a maximum of 6 minutes.

Several channels will be used for monitoring the condition of the crew. In fact, monitoring of physical condition, and the study of man's response to the conditions to be encountered have demanded a tremendous amount of attention.

To accomplish this, many miniaturized sensors have been developed in the last 2 years for checking the body

functions of men and animals in simulated or actual space environments. The usual measurements—heart potentials and heart beat rate, blood pressure, brain waves, body temperature, respiratory gasses, skin resistance, and many others are measured, but with new miniaturized transducers, and converted into signals that can be telemetered.

Preliminary animal space flights have shown us that physiological accommodation to the weightless state occurs after the acoustical and accelerative stresses of initial flight have subsided. As a result of these data, we are now acquiring confidence in the ability of the human body to cope with the expected and unexpected environmental hazards of the first space flight.

The problems of data transmission from space vehicles has caused another major break-through in our thinking—pretransmission data handling. Previous systems collected, coded, and transmitted a complete record of each data channel without regard to data content. Since many of these data did not change from one sample to the next, a highly redundant inefficient system resulted. This redundancy can be very desirable, providing cross checks on data, but a typical 30-channel system would require more than 2-kw average radiated power for analog transmission from Venus to earth—requiring over 400 pounds of power supply, even with anticipated improvements in the state of the art. If eliminating redundancy reduces the data to 10%, a 40-pound power supply would be adequate for the 200 watts of power to be radiated.

INDICATING AND INTEGRATING INSTRUMENTS

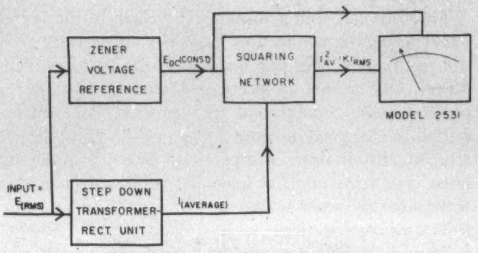
SEVERAL DESIGNS of magnetic support bearing systems for integrating watt-hour meters were announced in 1960. Two of the designs are of the magnetic repulsion type and one is of the magnetic attraction type. The magnetic bearing system is thus now available from all United States manufacturers.

Three new designs of demand registers were announced in 1960. One of these designs features a completely hermetically sealed motor. A feature of one of the other designs is a dual-drive gearing arrangement which eliminates open time between intervals.

The application of taut band suspension bearing systems was broadened in 1960 to include all electrical switchboard instruments with 100-degree and 250-degree scales. Increased sensitivity, elimination of friction errors, and reduced maintenance will benefit users.

Digital instrumentation was developed and broadened in application particularly for applications involving counting and speed, such as in paper mill drives. Preciseness of counting means through electromagnetic pick-ups and toothed wheels or gears made it possible to measure draw-speed between rolls of paper machine drives to resolution and accuracy of the order of 0.1%. This makes great savings possible in minimizing "cut and try" during start-up with different types of paper.

Thermal voltage converters, each consisting of a deposited carbon resistor in series with a thermoelement in a coaxial line, have been developed at the National



Block diagram of rms rectifier circuit.

Bureau of Standards (NBS) for measurements of rms voltages from 1 to 200 volts. Their configuration permits an extended frequency range and makes it possible to compute the effect of residual reactances. Extensive tests indicate satisfactory agreement with computed a-c/d-c differences to 40 mc.

These voltage converters are ordinarily used to make a-c/d-c tests of other thermocouple instruments, but can be used for a-c measurements as well. They are inexpensive and easy to construct. An accuracy of 0.1% or better is possible to at least 10 mc and 0.2% at 40 mc.

Expanded scale a-c voltmeters with ranges of plus and minus 10% of mid-scale utilizing Zener diode reference were announced in 1960. These new designs are practically insensitive to temperature change and respond to rms in the presence of large harmonics over wide bands of frequency.

TELEMETERING

THE DEMANDS of the electrical utility and process industries as well as the aero-space programs for the rapid acquisition and processing of large volumes of data have accounted for the major part of the development and application work recorded in 1960.

Since most modern data-processing techniques employ digital information, the development effort has been directed toward compatibility with digital processing equipment. The prime objectives have been higher speeds of transmission, increased multiplexing, greater accuracies, and a general miniaturization through the use of solid-state components.

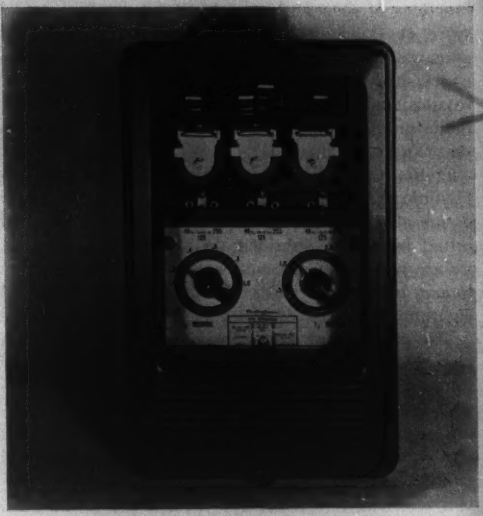
Developments have continued on conventional analog telemetering systems primarily in the areas of improved reliability and higher speeds to permit the extension of these systems into the digital field. Pulse code modulation systems have received special attention with several large installations being placed in operation.

Transducers and sensing elements of many types have been reviewed, evaluated, and recorded in the literature. Various innovations of analog to digital encoders, decoders, and electronic commutators appear in the literature, all aimed at the digital processing markets.

The present 200-mc transmission band is already crowded and one leading manufacturer has started development of components for the 2,200-mc band.

This year has seen a substantial growth in industrial telemetering in connection with the supervisory control of pipeline pumping stations in the petroleum industry. One system in particular, through the use of pulse duration modulation telemetering, has been installed for the remote control of down-stream pumping stations. Installations of supervisory control employing pulse width modulation telemetering systems are also being used by water works utilities for the remote control of isolated stations.

The use of small digital computers in the process industries to control processes is evidenced by the recording of a system which controls in-line blending. This system transmits pulse-coded information to and from the computer.



Timing relay using solid-state components.

Power

INSULATED CONDUCTORS

THE EXTRA-HIGH-VOLTAGE Field Testing Project at Cornell University reached a significant stage during the past year in that the construction phase contract was completed. This project, designed to proof-test under load cycles, cable systems capable of transmitting loads under American conditions in the order of 500 mva or more at voltages of 345 kv or greater, is being jointly sponsored by the AEIC and the EEI (Association of Edison Illuminating Companies and the Edison Electric Institute). The Cornell EHV Test Station was essentially built by mid-August 1960 when the high-voltage busses were initially energized with application of voltages extending over the full range anticipated in the 3-year schedule of testing.

Breed plant of the American Electric Power System. First unit rated 475 to 500,000 kw.

This marked the culmination of a long period of activity on the part of the Joint AEIC-EEI-Manufacturers Steering Committee comprising representatives of six AEIC companies, two EEI companies, four cable manufacturers, and two pothead manufacturers, appointed in 1956 when the AEIC and EEI approved the project, contingent upon raising at least $300,000 by direct subscription by large privately owned electric utilities in the United States interested in ehv cable. The enthusiastic acceptance of this project is reflected not only in the fact that the ultimate outlay by the individual utilities, together with the specific AEIC and EEI contributions, will be in the order of $700,000 by the end of the scheduled test program in 1963, but also in the manner in which the many equipment manufacturers made available components essential to the construction of the Cornell Test Stations either at no cost to the project or at prices considerably below cost or normal pricing levels. The cable manufacturers have each made expenditures in the order of $500,000 in one way or another in their preliminary research and development work, factory tests and construction of their cable samples, which were made available at no cost to the project. Accordingly, the completed Cornell EHV Cable Test Station represents an over-all expenditure of about $3 million.

POWER GENERATION

THE TREND in machine size is still upward. This is equally true for average size as well as maximum size, which has now reached 800,000 kw.

While Eddystone no. 1, designed for 5,000-pounds-

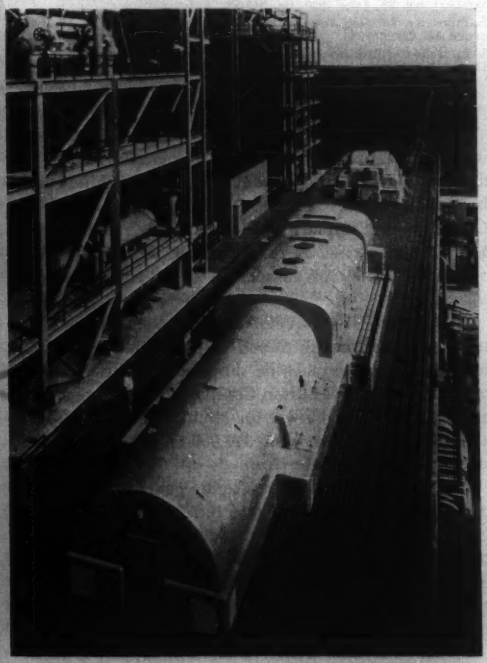
per-square-inch pressure and a steam temperature of 1,200 F is in service, the industry has retreated from these high values. Eddystone no. 2, Breed and several other stations employ 3,500 pounds for the initial pressure. It appears that this is a plateau above which few designers and application engineers are willing to go until the availability record of this equipment, including both boilers and turbines, has been improved so as to justify a further advance. Temperatures have also moderated and 1,050 or 1,000 with double reheat has become quite popular.

There has been steady progress in the development of atomic power plants. The apparent ease with which Dresden was placed in service is evidence that many of the numerous start-up problems have been solved.

In 1960 there was renewed interest in hydroelectric developments. Surveys showed some additional sites susceptible to economical development. Work was started on the construction of several large pumped storage installations.

Much study has been devoted to finding a solution to the increasing importance of the peaking problem. The larger high-pressure and high-temperature machines appear to be less flexible in meeting the rapid load changes which appear to be increasing in severity every year. One of the less controversial methods of solving the peaking problem appears to be the pumped storage unit.

Master station of solid-state supervisory equipment with cover removed from one chassis and with two of the modules removed for inspection.



Continuing the trend toward more and larger outdoor steam turbine-generator installations, this 292,000-kva 60-psi hydrogen pressure Allis-Chalmers unit is in operation at the North Houston Station of the Houston Power and Light Company.

There has been a strong trend to eliminate all spare auxiliaries. Turbine drive for auxilaries is again making a strong bid after losing ground for 25 years. One new unit under construction has the exciter on the main shaft and employs turbine drives for both fans and feedwater pumps. Other important installations have the feedwater pump drive off the main shaft.

Progress in the automation of power plants has been exceptionally rapid. While greatest progress has been made with gas and oil fired plants, the coal burning plant is making almost as much progress. The automated power plant is bringing about the development of many new concepts of control of the boiler and the turbine.

These uprated units bring with them many problems affecting both themselves and the systems which they supply. Users and manufacturers are jointly analyzing these problems and seeking the most satisfactory answer from the viewpoint of over-all economy.

RELAYS

THE USE of static components in protective relays is increasing. In addition to the all-static, phase comparison and generator differential relays announced in the last year's survey, the all-static, overcurrent relays were placed on the market. Research and development work is being done to extend the line of all-static relays to other applications.

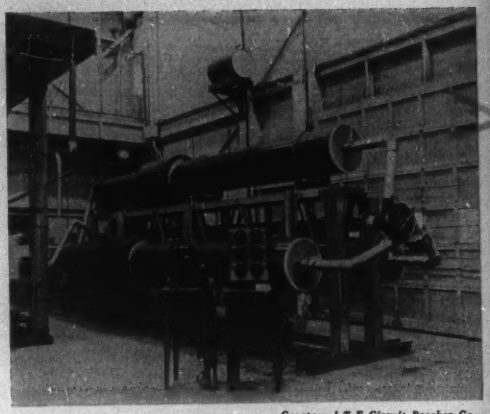
Since static devices are more sensitive to voltage surges, greater interest is being centered around the problem of surges developing in the control circuit. Studies are being made in order to learn more about

their origin and means of reducing or eliminating their influence.

The evolution of electric transmission and subtransmission systems is always closely followed by the relay engineers. As the electric system grows, multitapped lines develop, and at the same time the need for faster fault clearing becomes more imperative. The a-c pilot wire relay long has been the favored protection plan for many lines where fast fault clearing was desired. But this scheme has its limitations as it is not applicable where longer distances are involved or for multiterminal lines with possible power infeeds at all terminals. A new scheme has been presented.[1] using 2-way repeater technique of the communication channel where the permissible limit of a-c pilot wire application can be increased.

Other approaches to the solution of the complex problem of the multiterminal line protection are the various methods of transfer tripping. The use of audio tone over metallic telephone circuits or microwave channels is finding increased application. Several methods of transfer trip schemes have been proposed and are being used to fit the particular application.[2,3]

The performance of the communication circuits used for pilot wire relays is a vital factor in the reliability and security of the protection system. The AIEE Special Publication—"S-117—Application and Protection of Pilot Wire Circuits for Protective Relays" was released during the Summer of 1960 and is intended to acquaint the industry with the problems of metallic communication circuit protection used with the pilot wire relays.



Courtesy I-T-E Circuit Breaker Co.

Laboratory set-up to prove adequacy of engineering design of 10,000-ampere 23-kv liquid-cooled isolated-phase bus assembly for generator connections.

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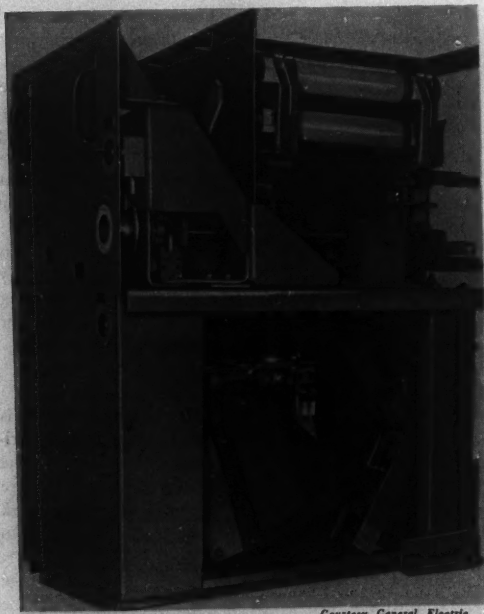


Courtesy General Electric

Side view of rollout-load-interrupter switch and current-limiting fuse assembly with insulating barriers removed showing component parts.

ROTATING MACHINERY

WATER COOLING of the copper conductors in the stator windings of turbine generators was employed for the first time in two large conductor-cooled machines built by General Electric for the Phillip Sporn Plant of the Ohio Power Company. The generators, rated 265,000 kva, 16,500 volts at 30 psi hydrogen pressure, are part of a 450,000-kw cross-compound steam turbine-generator unit.

Application of conductor cooling to large 1,800-rpm turbine generators continued in the 234,000-kva 45-psi hydrogen pressure machine supplied by Allis-Chalmers to the Consolidated Edison Company. This machine has a multistage axial blower for circulating the hydrogen and is one element of a 340,000-kw cross-compound steam turbine-generator unit.

A newly developed diesel-engine generator unit supplying power to a motor driven refrigeration compressor is contributing to the replacement of iced refrigeration railroad cars. Built by Electric Machinery, the generating unit operates at either 1,800 rpm, 60 cycles or 1,200 rpm, 40 cycles, for two different cooling rates. The generator and its exciter are completely brushless. The system, with its static exciter excitation supply, is inherently self-regulating within ±10% voltage for each speed.

Several unique drive systems were installed by Allis-Chalmers at the U.S. Navy's David W. Taylor model

basin. In one installation, motor-driven blowers supplied with power from induction frequency converters over the range of 80 to 8 cps assist in producing waves of controlled amplitude and wave length in a rectangular maneuvering basin. Models are towed through the waves from an overhead bridge to test model performance in rough water. Acceptance of the equipment was based largely on initial computer design studies demonstrating that the exacting requirements of acceleration rates, speed control, and speed stabilization could be met.

SUBSTATIONS

DEVELOPMENTS THIS YEAR were primarily toward achieving greater economy in substation installations of both smaller and larger types. This is reflected in such subjects as the exchange of information permitting greater design standardization between utility companies. It is believed that standardization methods and techniques applied within individual companies can be applied between different companies on a wider scale than has been the practice to date. Standardization and mechanization of foundations is another example of revised practices leading to more economical installations.

A review of the factors affecting the selection and methods of installing control cables within substations and switchyards has been initiated with the hope of encouraging more uniform practices, improved reliability, and economy.

Considerable interest is developing in methods of achieving optimum long-rate economy for distribution substations which will initially serve a relatively small load, but with provision for expansion to serve much larger future loads. Installations of this type are associated with primary distribution voltages of 12 or 13 kv and higher, particularly when served by subtransmission voltages of 115 or 138 kv.

Particularly useful and significant information is anticipated from a series of tests on the short-circuit forces resulting on single and bundled strain bus conductors, insulators, supports, and equipment terminals.

The following subjects have been of continuing interest this year with further exploration expected: (1) Factors affecting the acceptance design and construction of substations in residential and urban areas; (2) Use of aluminum for busses and for substation structures; (3) Increased use of supervisory control and data logging equipment; (4) Optimum design and safety of substation grounding grids; and (5) The developments on ehv substations and the test installations now in progress.

A significant advance in supervisory equipment has now been made by the development of the solid-state space-code selector system. This new equipment, which is now available, uses transistors and other solid-state elements mounted on plug-in modules. Due to the reduction of moving parts, field adjustments and maintenance are practically eliminated. Floor space requirements are reduced by as much as 50% and weight reductions up to 25% can be obtained compared to the all-relay design.

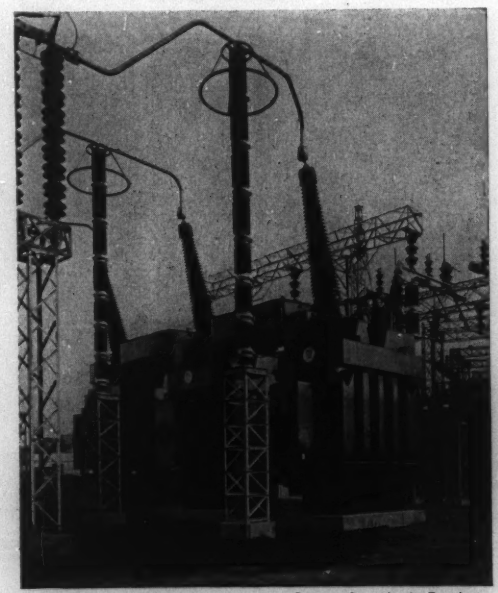
SWITCHGEAR

DURING THE PAST YEAR, the I-T-E Circuit Breaker Company has completed development engineering for a 10,000-ampere 23-kv liquid-cooled isolated-phase bus assembly. This development enables very substantial reductions in the initial cost of the bus connections for large electric generators.

In this equipment a cooling fluid is passed through hollow bus conductor. The fluid is inserted at the generator terminals and passes through the length of the bus where it is collected and passed through a heat exchanger before being returned to circulate again through the bus. Both insulating oil and water have been tested and found satisfactory as cooling media. The high thermal capacity of these materials enables the removal of heat from very long bus runs with simple and inexpensive liquid handling equipment.

To prove the design, a 27-foot-long 3-phase assembly of bus, rated 23 kv, 10,000 amperes, was operated with a variety of coolants and flow conditions. This unit contained conductor members of a size normally used for 3,000-ampere self-cooled buses. The assembly operated satisfactorily at 10,000 amperes without exceeding permissible temperature rise limitations. With water as a cooling medium, the temperature gradient along the bus conductor was measured at 0.0064 C. Less than 0.25 hp was required to circulate the liquid through the 3-phase assembly.

This development indicates the feasibility of low-cost



Courtesy Pennsylvania Transformer Division, McGraw-Edison Company

The 460-kv transformers supplied for Penelec's ehv line are shown here from the high-voltage side. Installed at the eastern end of the line, the autotransformer bank is rated 60,000 kva, 460–115 kv.

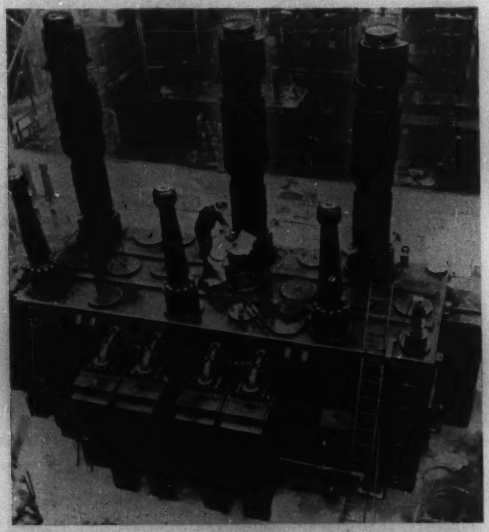
isolated-phase bus connections for large electric generators utilizing forced liquid cooling of the bus conductor.

A novel solution is now available to the problem of obtaining reliable tripping power, without the use of an operating or tripping battery in metal-clad switchgear using medium-voltage power-circuit breakers, particularly for unit substations. This so-called auto-charge trip device uses a capacitor similar to the conventional capacitor trip device, but in addition it incorporates a small selfcontained standby source of power from a relatively small, sealed, rechargeable nickel-cadmium battery and d-c voltage amplifier which can keep the capacitator fully charged for several days in the event of an a-c power failure. Small size and practically maintenance-free operation have been secured in this trip device by the use of solid-state components of the latest design with modern circuit techniques.

Increased use is being made of medium-voltage roll-out load-interrupter switch and current-limiting fuse equipments for load-center unit substations, small power and lighting transformers and light-duty incoming service or outgoing feeder circuits. These designs are available with manually operated stored-energy mechanism which utilizes stored energy for both the complete opening and closing operations of the switch. These switches may be closed against short-circuit currents as high as 40,000 asymmetrical amperes at 2.4 to 13.8 kv.

SYSTEM ENGINEERING

THERE IS DEFINITELY A TREND toward use of digital computers in practically all phases and areas of



A new development winning utility company approval is the adoption of this bushing-mounted load-tap changing (LTC) equipment. This LTC equipment includes a different arrangement of contactors as compared to conventional types. This economical change eliminates the need for a series transformer, in turn, providing for smaller dimensions, up to 10% lighter weight and 15% lower losses.

This Allis-Chalmers 5,000-kva 5,000-cycle dry-type transformer has a 5,000-volt dry-type epoxy insulated primary winding. The secondary will be formed by the high temperature plasma of the C Stellarator (a hydrogen fusion device) now being assembled at Princeton University.

System Engineering work. It has been only a relatively few years since the importance of this new tool was recognized in this field, but already it seems to dominate the thinking of new developments. During the past year, three-quarters of the papers sponsored by this Committee involved the use of digital computers. Nearly half of the papers for the Power Industry Computer Application Conference in November 1960 were sponsored by this committee.

Associated with the computer activities, a third survey has been made of the electric utility applications of digital computers. This is expected to be presented at the 1961 AIEE Winter General Meeting. A comparison with the two previous surveys indicates the rapid growth of this activity as follows: first survey, 1957—92 programs; second survey, 1958—196 programs; and third survey, 1960—335 programs.

Computers are used extensively in the study of the economics of power-system design and operation. They permit much more complete comparisons of various plans of system expansion and the selection of generation. They are also used to determine the most economic scheduling of generation considering such problems as combinations of steam and hydro generation and the effect of line losses on widely separated power sources. Computers are being used for "on-line" or continuous load control and economic dispatch and are rapidly being incorporated into other forms of power plant and power system data logging and automation.

In connection with system planning, an important guide is provided by the experience of the industry as measured by probability methods. A thorough review of this subject was published in the form of a committee report entitled "Application of Probability Methods to Generating Capacity Problems." This subcommittee has prepared a standardized outage report form with the hope that its use will be adopted by several companies with the result that more consistent information will be available.

The System Controls Subcommittee is working on a Terminology Project in an effort to develop a standard language for discussing and describing the automatic

equipment which has been and is being developed for controlling the production and distribution of power.

Probably the word which is used most often in discussing the developments in the field of system engineering would be "automation."

TRANSFORMERS

THE DEVELOPMENTS IN TRANSFORMERS during 1960 emphasized insulation systems and processing, noise measurement and reduction, high-voltage load-tap changers, and an advance in the voltage and kva rating of transformers.

Several manufacturers are rating their transformers at both 55 C and 65 C, the 65 C rating generally being 12% above the 55 C rating. They state that the life with new insulation systems or new processing will be the same or greater, at the higher load and temperature, as older transformers at 55 C.

General Electric and Pennsylvania Transformer Division of McGraw-Edison Company built 60-mva transformer banks for operation at 460 kv on the Pennsylvania Electric system. These are the highest voltage units built for a utility company in the United States.

Westinghouse has announced the design of a 600-mva, 20- to 138-kv generator transformer for a Midwestern utility. It will weigh approximately 320 tons and will be shipped complete except for bushings and coolers on a "Schnabel" transformer car.

High-voltage load-tap-changing equipment is being manufactured in the United States which will change connections at the low-voltage tap of autotransformers. This eliminates the use of a series transformer, thus reducing size and weight of the equipment.

Westinghouse introduced the Unoreg voltage regulator for distribution systems. It is designed for solving the voltage regulation problem through a systems approach. Unoregs can be used to buck the voltage at the feeder head and boost it at the far end.

Sound levels in transformers are being studied by working groups of the Transformers Committee. Manufacturers are increasing their shipment of transformers where reduced sound levels are obtained by sound-reducing panels, complete enclosures, and hydromechanical sound-shunting systems. These methods can provide a required sound level at lower cost than the conventional reduction of flux density in the core.

TRANSMISSION & DISTRIBUTION

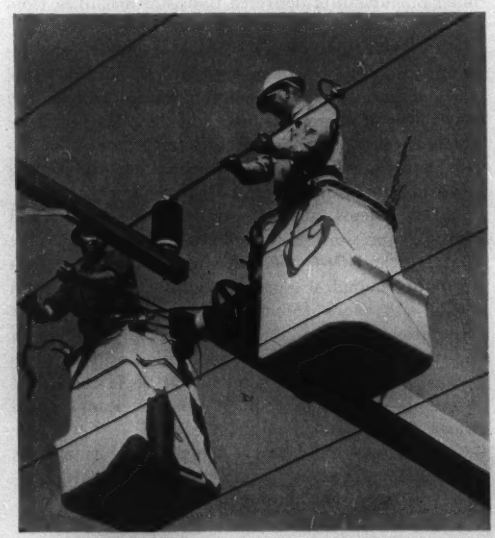
WHILE SIGNIFICANT ADVANCES were made on many fronts, the year 1960 will be best remembered as the year in which construction was completed on several experimental ehv transmission lines whose purposes are to extend the frontiers of knowledge in this field. These lines will be the prototypes and forerunners of future lines at extra high voltages which will economically link America's rapidly expanding electric generation with its ever-increasing loads.

In Berkshire County, Mass., General Electric and nine co-operating companies completed a $7.5 million research installation involving a prototype power transmission system capable of operation at voltages in excess of 650 kv. Instrumentation enables tests to be made of corona, radio noise, mechanical performance, and lightning response, with provision made for various phase spacings and conductor diameters and configurations.

To the north, the 460-kv Coldwater test facility of the Hydroelectric Power Commission of Ontario was nearing completion, while to the south, in Pennsylvania, another 460-kv experimental test line was energized on September 30, 1960, and became the first in this country to carry power at this voltage as part of an established grid. This latter line, built by the Pennsylvania Electric Company and equipped with the cooperation of Westinghouse and a number of other companies, is 13 miles in length and comprises 14 different structure designs. Definitely experimental in nature, it will be used to evaluate the relative performance and economy of four different types of conductor used in the line in bundled configuration.

Out in Colorado, the test line of the Public Service Company of Colorado continues to accumulate data on ehv phenomena at high altitudes. This line, constructed at an average altitude of 10,500 feet, has utilized three different conductor configurations in experiments to date.

In the heretofore prosaic field of maintenance of high-voltage lines, the American Electric Power Company announced the successful employment of a modi-



Courtesy American Electric Power System

Working barehanded on a live wire, two linemen repair a 34,500-volt line near Findlay, Ohio. They stand in nonconducting Fiberglas buckets supported by an insulated boom. Protected by insulation from the difference in voltage between ground and the wire, the men are charged at line voltage by connecting the bucket's metal-mesh lining to the wire. Bucket rig is mounted on a truck, can be used in all but the roughest country.

One of three bays of the Convair-Astronautics analog computer laboratory.

fied faraday cage to enable linemen to work on energized lines barehanded. Equipment consists of a truck-mounted insulated boom carrying a shielded bucket in which the lineman is placed in proximity to the work. Bucket, and lineman, are brought to the potential of the live parts by a metallic connection enabling the necessary work to be done barehanded.

Science and Electronics

COMPUTING DEVICES

WHILE TRANSISTOR COMPUTERS have been announced for several years, 1960 saw the first commercial installations of standard line machines. Almost every computer manufacturer delivered transistor machines, from the large LARC to the small Packard Bell *PB-250*.

With increasing circuit speed and reliability, computer installations containing several machines are being replaced by a single more powerful system. The availability of microwave links and the release of Dataphone encourage the linking of a large number of distant points in a single data-processing network, leading to greater use of on-line rather than batch processing.

Larger systems caused the evolution of satellite and multiple-processor computers. The satellites, like the IBM *1401* and *CDC 160*, can not only preprocess data for more economical transmission, but can also perform certain tasks more economically than the more flexible large machines. The concept of a complex of processors that can grow with an application and that can perform certain tasks more reliably or efficiently has led to multiple-processor computers like the Ramo Wooldridge *RW-400* and Bendix *G-20*.

Control computers have come of age during 1960. Fifteen different computer systems are presently available with more to come in the near future.

1960 saw the successful marriage of electronic computer systems with character recognition equipment. Deliveries of magnetic-reading check sorters herald the nation-wide network of banking systems that can communicate via the Federal Reserve System. At Arizona Public Service Company in Phoenix, printed business documents were scanned optically as input for the digital computers.

Among the technical advances of this past year have been the announcement of thermoplastic recording and the use of thin films as logic components. Machines have been constructed for language translation, and attempts have been made in the design of learning machines.

Along with the new equipment developments came new uses for analog and digital computers. Computers were used for planning and control of complex research and development programs. One such effort, PERT (Program Evaluation and Review Technique) is a statistical technique for quantifying the technical uncertainties associated with activities essential for timely achievement of program deadlines. Repetitive analog computers have been applied to the solution of partial differential equations, to the determination of boundary values, to optimization problems, and to statistical studies.

In the laboratory, efforts are being directed toward the next breakthrough, the gigacycle computer. Tunnel diodes and thin films have become standard components for the advanced circuit engineer; and spurred by Project Lightning, breadboards of arithmetic elements and memories are being tested that operate 500 times faster than their present counterparts.

ELECTRONICS COMMITTEE

THE PAST YEAR has seen some significant advances in the state of the art of devices to convert solar, nuclear, and chemical energy directly to electric energy. Much impetus in this field has been generated by the power requirements for satellites and space vehicles. Here the predominant considerations are the high-vacuum gravityless environment, the need for extreme reliability and the desire for maximum conversion efficiency because of the difficulties of rejecting waste energy (solely by radiation).

The energy package which is most highly developed

Single-cell and triple-cell battery assembly of Gulton Industries new long-life, hermetically sealed, rechargeable nickel-cadmium battery developed for outer space applications. The white seals are one of the key features of this new battery.

is the galvanic battery. Primary cells are, however, limited to missions of short duration during which time they are completely discharged. For long-time missions, secondary storage batteries are used in conjunction with a charging source. The most advanced system for small amounts of power is the solar cell-sealed nickel cadmium battery power source. Advances in solar-cell technology have led to cells having efficiencies as high as 15%. Recent advances in the battery field have led to a truly hermetically sealed nickel-cadmium battery utilizing a reliable ceramic-to-metal seal and an internal construction capable of continuous indefinite overcharge at 1 ampere for a 5-ampere-hour cell.

Improved semiconductor materials have led to thermoelectric devices capable of 12% conversion. When cascased (i.e. connected in series in the heat path with each element operating in its optimum temperature range) a device with 18% over-all efficiency has been realized. For high-temperature sources thermionic devices have been developed and are being made in production quantities. Both thermoelectric and thermionic devices can operate from a solar energy collector but their real potential lies in their use with radioisotope sources. Large power output devices in the thousands of watts range are achieveable.

Considerable development of fuel cells has been reported. The hydrogen-oxygen systems utilizing porous carbon electrodes operating at normal ambient temperatures and pressures, and those using porous nickel electrodes operating at high temperatures and pressures, have achieved considerable engineering maturity. Other fuel-cell systems using bromine and other redox couples are progressing. The regenerative fuel cell utilizing ion exchange membrane electrolytes and galvanic decomposition of water to H_2 and O_2 has been considerably developed.

Magnetohydrodynamics as a means of direct energy conversion has been shown to be feasible but is restricted to large power outputs—megawatts—for practical use. Fusion power with conversion to an electrical output by coupling through a plasma continues to be the subject of research.

In the television field, development of an image orthicon tube with a thin-film magnesium-oxide target in which conduction of the current that corresponds to the light and shadow portions of the picture is by electrons rather than ions increased the response to such a degree that the same resolution is attained at 1/10 the illumination.

The new target eliminates the "stickiness" (retention of the picture image for longer than the normal frame period) that is due to depletion of ion carriers in glass targets as well as permanent "burns" resulting from excessive light.

NUCLEONICS

INNOVATIONS IN ACCELERATION DESIGN have increased the energy, the useful current, and the versatility of machines available for nuclear research. With the incorporation of improved ion-source techniques and gas stripping in the tandem Van de Graaff, the precision of this high-voltage machine is now available at 12 to 13 megavolts (mv); a dozen such machines are in operation or should be completed in 1961.

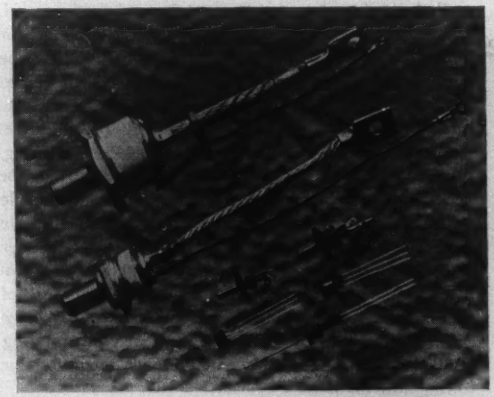
A whole new generation of cyclotrons is also in the making; they extend the favorable duty cycle (high current) of the fixed-frequency operation to proton energies from 20 to possibly 900 megelectron-volts (mev). Azimuthal variations in the magnetic field provide the necessary focusing forces while the average magnetic field increases with radius to maintain isochronism at relativistic energies. Azimuthally-varying-field cyclotrons to operate in the 30- to 100-mev range are scheduled for completion by early 1962 at the University of California, both at Los Angeles and at Berkeley, at the University of Colorado, and at the Oak Ridge National Laboratory. The latter is also testing electron models of an 850-mev proton machine.

In linear accelerators, improved r-f technology provides, for example, over 1 ampere of electrons at 55 mev at Applied Radiation Company and, in the projected "two-mile" accelerator at Stanford University, Stanford, Calif., promises the acceleration of electrons to 20 billion electron volts (bev). The successful application of the alternating gradient focusing principle has led to record-high energies. An alternating gradient synchrotron at Cambridge, Mass., should soon be providing 6-bev electrons.

On July 29, 1960, the alternating gradient synchrotron, the large particle accelerator, of Brookhaven National Laboratory, Upton, Long Island, produced a beam of protons at an energy of more than 30 bev. The successful culmination of 8 years of study, design, and construction gives the scientists the world's highest energy machine for study and research on the question of nuclear structures.

SEMICONDUCTOR RECTIFIERS

The Semiconductor Rectifier Committee is planning a Technical Conference to be held at the same time as the Fall General Meeting in 1961 and is planning to



Size variety of silicon-controlled rectifier cells available.

review the state of the art and contributions to the industry which are new since the last Technical Conference sponsored in Chicago 5 years ago.

The year 1960 saw the silicon cell brought closer to home when one of the "Big 3" automobile manufacturers switched their production from the conventional d-c generator system to the alternator-rectifier combination a-c system for supplying power to charge batteries in the automobile. Alternator rectifier systems have been used for many years for supplying the high power requirements of trucks, taxi cabs, police patrol cars and many of the deluxe passenger cars which had unusual major power requirements due to air conditioning, power windows, and seats and auxiliary electric equipment.

A conventional alternator rectifier combination has an alternator with a 3-phase output and requires six silicon cells. Three of the silicon cells are positive base and three negative base. One side of the bridge is insulated from the housing and the heat sink itself is an integral part of the housing. Alternator-rectifier system on the modern automobile permits charging of the battery, even though the car is at idling speed. A conventional generator does not normally charge unless the idling speed is set unusually high. Modern day traffic, being what it is, frequently results in a low charged battery condition. unless an alternator rectifier system is employed. Until the silicon rectifier cell became a commercial product available to the public at a nominal cost, an alternator-rectifier system was not a practicality. Early-day alternator rectifier systems employed a selenium rectifier to convert the a-c to d-c; space, cost, and an inadequate supply of selenium prohibited widespread usage of the system. The silicon cell solved all of these problems and it is predicted by the industry that every car will be so equipped in the future.

Another product being widely recognized as an industrial practicality during the year 1960 was the silicon-controlled rectifier cell. Since the introduction of silicon-controlled rectifier cells in 1957, these extremely versatile devices have been increasingly used in all segments of industry. Among current applications for controlled rectifiers are motor armature and field control, temperature control, light dimming, static inverters for aircraft and radar pulse modulators. Although some equipments are being manufactured, we will see extended utilization in the next few months in such applications as static switches, voltage and current surge-protector circuits, high-frequency fluorescent lighting, ultrasonic generators, and adjustable speed drives for heavy industry. The silicon-controlled rectifier has made possible improved excitation equipment for adjustable voltage mercury-arc rectifier units. Ignitron rectifier units, using silicon-controlled rectifier excitation equipment, are ideal for d-c motor-drive service because of the increased speed with which their output voltage can be adjusted. Equipment of this type totaling 123,000 hp has been delivered by one manufacturer for rolling-mill main-drive service.

The silicon rectifier also found application in the steel industry in 1960. One such installation was a 1,000-kw 250-volt d-c silicon rectifier. This silicon rectifier is water cooled through a water-to-air heat exchanger. The heat exchanger is a closed system and filled with antifreeze. Continuous deionization is employed to prevent electrolysis and corrosion. The rectifier is equipped with rigid voltage division and forced current balancing. Each cell is individually protected by current limiting fuses. Fuse monitoring is obtained without conductive connection to the power circuits.

To illustrate the tremendous power now being furnished by silicon rectifier equipments, we cite another installation for an aluminum smelting application. This particular application is rated at 10,000 amperes, 600 volts d-c. The key to this rectifier was the development of a 1,000-PRV silicon cell, making it possible to achieve the 6,000-kw rating with only 312 silicon cells.

The Semiconductor Rectifier Committee sponsored two technical sessions during the year. One at the Winter General Meeting and one at the Fall General Meeting. It plans to sponsor three sessions in 1961: at the Winter General Meeting, the Summer General Meeting, and the Technical Conference during the Fall General Meeting. The Committee has sent the proposed definitions for semiconductor rectifying components to the Standards Committee of the AIEE and it is hoped that they will become a standard in 1961. Committee members have been active in their participation at the International Electrotechnical Commission (IEC) meetings and it hopes to have four and possibly five representatives attending these meetings in 1961.

SOLID-STATE DEVICES

RESEARCH AND DEVELOPMENT on thermoelectricity has progressed rapidly during the last year. In conjunction with the Bureau of Ships, Carrier Corporation has designed, built, and tested an experimental thermoelectric module which can heat or cool and dehumidify air. Designed for application on nuclear-powered submarines, the module consists of a thermoelectric panel sandwiched between air and water heat-exchange surfaces. Requiring only electric energy to operate, heating or cooling is provided as required merely by reversing direction of current flow. Designed for modular construction, large systems can be comprised of multiple panel assemblies.

The largest thermoelectric generator ever built in the United States was constructed for the Bureau of Ships by Westinghouse. It is the forerunner of large-scale direct conversion thermoelectric power supplies for military and commercial application. Each 2,500-watt subsystem has its thermocouple assemblies arranged around a kerosene burner, with water cooling on the outside surface. In addition to the 5,000 watts usable output, the generator supplies power for the fuel and coolant pumps and is completely selfcontained. The generator performance demonstrates that quiet ship propulsion and remote nuclear-fueled power supplies are now feasible.

Network Inverse and Mesh Transformation Matrices

N. SATO
ASSOCIATE MEMBER AIEE

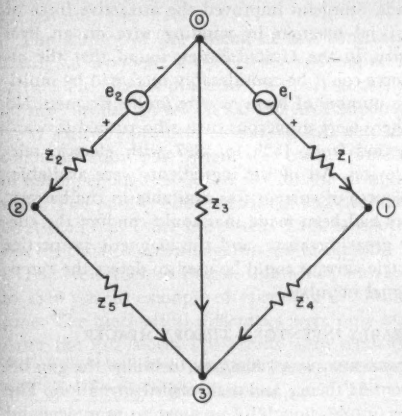


Fig. 1. (*left*) Given network.

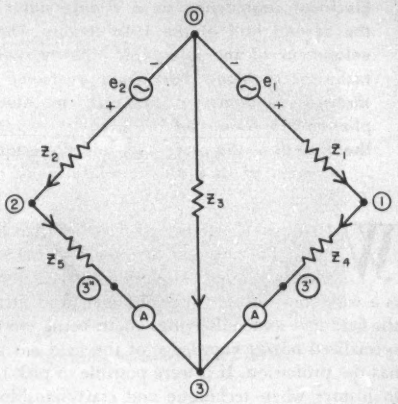


Fig. 2. (*right*) Addition of ammeters to the given network.

THE importance of matrix inversion has become rather apparent in solving power system problems digitally. Computation of the inverse matrix is quite involved, however, and even with the largest computer, the inversion time runs high. The outright inversion of an n by n matrix requires operations proportional to the cube of n. For this reason, its use has been limited to certain repetitive-type problems such as the short-circuit study. In many instances, by taking advantage of favorable network configurations and using network techniques, matrix inversion can be obtained much more efficiently than with the outright inversion method.

Modification of a given network by adding zero resistance ammeters and zero conductance voltmeters allow the definition of nonsingular transformation matrices, A and C (Figs. 1, 2, and 3). The nodal matrix A and the mesh matrix C then give:

$$C = {}_tA_T)^{-1} \tag{1}$$

Using C and A the following equations are determined:

$$Z' = C_T Z C \tag{2}$$

$$Y' = A_T Y A \tag{3}$$

Z and Y are the impedance and admittance matrices of the given network respectively. By means of the relation given in equation 1, equations 2 and 3 can be shown to be inverses of each other.

$$Z' = (Y')^{-1} \tag{4}$$

$$Y' = (Z')^{-1} \tag{5}$$

Applying the method of matrix inversion by partitioning on equations 4 and 5, it is seen that Z' and Y' can be reduced using the Gauss elimination scheme to yield inverse matrices of both the mesh and nodal equations of the given network. The effectiveness of this method of elimination over the outright matrix inversion depends entirely on the network configuration.

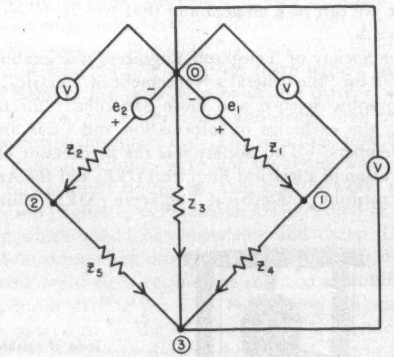


Fig. 3. Addition of voltmeter branches to the given network.

Digest of paper 60-780, "Digital Calculation of Network Inverse and Mesh Transformation Matrices," recommended by the AIEE System Engineering Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 19-24, 1960. Published in AIEE *Power Apparatus and Systems*, Oct. 1960, pp. 719-26.

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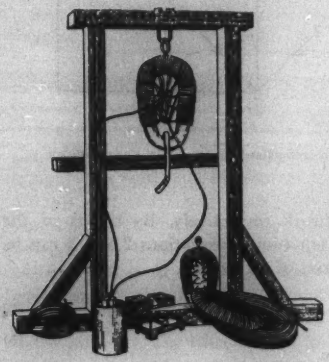
The Beginnings of Electrical Engineering

HAROLD SHARLIN

Electrical engineering as a science dates from the second half of the 19th century. The development of the telegraph industry, with its technical problems that were overcome only through fundamental research in electrical phenomena, furnished the greatest impetus to the growth of the profession and the establishment of its professional societies.

WHAT is electrical engineering? When did it begin? The answers to these two questions are closely related. Modern electrical engineering is a wide and diffuse field. The men who first defined the field had some misgivings about being too narrowly specialized but as knowledge of the field has grown so has the profession. If it were possible to pick the point in history when technique and craftsmanship became science and engineering, we could gain some insights into a complicated field. Although we cannot pick a point, we can pick an area and that area is the electric telegraph.

The Society of Telegraph Engineers was established in 1872 for "the general advancement of Electrical and Telegraphic Science, and more particularly for facilitating the exchange of information and ideas among its Members."[1] This Society was the predecessor of the Institution of Electrical Engineers (IEE) and the American Institute of Electrical Engineers (AIEE). But the telegraph was invented in 1837. Why was there no need felt for such an organization of engineers until 1872?



Some of Joseph Henry's electromagnets, made in 1828, were wound with many turns of insulated wire. (Still preserved at Princeton University, Princeton, N. J.)

Within a few years of Oersted's discovery of the magnetic effect produced by an electric current and Ampere's description of electromagnetic force, men were building electromagnets which could lift astonishingly heavy loads. Sturgeon improved the attractive force of these artificial magnets by winding wire on an iron core. Henry, in the United States, found that the attractive force could be considerably increased by multiplying the number of loops of wire on his magnets. No wonder there were numerous men who rushed forward in the period from 1825 to 1837 with electric telegraphic devices. All of the ingredients were available: a steady source of current was available in the battery, conductors had been made that could conduct the current over great distances, and the magnetic properties of an electric current could be used to detect the reception of signal impulses.

EARLY INVENTORS' THEORY MEAGER

NO ENGINEERING WAS NECESSARY to bridge the gap between scientific theory and a successful invention. The theory was simple enough for an amateur to understand and the device needed only to be a simple mechanical application of what was already known. It is significant that the two men most responsible for the successful introduction of the telegraph knew hardly anything about electrical science. William Cook, in England, had assisted his father in anatomical studies before he began work on the telegraph. Morse, the American, was a painter.

Each inventor worked on slightly different principles. Each eventually required the services of an experimental physicist. Cook's device was a direct application of Oersted's discovery. Oersted had found that a magnetic needle tended to orient itself perpendicularly to the wire. If the current in the wire was reversed, the needle would point in the opposite direction. Cooke devised a diamond-shaped board with five magnetic needles spaced across the widest part. Each needle was under the influence of a separate wire. The needles would pivot to the right or the left depending on the direction of the current sent from the transmitting end. The needles served as arrows. Currents would cause two of the needles to move and the intersection of lines through the needles would indicate a letter or number.

Cooke found it necessary to seek the help of Charles Wheatstone, the physicist. The two men were granted a patent on their telegraph instrument in 1837. Their device had the advantage of simplicity of operation. There was no need to train operators since all they had to do was to be able to read the alphabet. The Cooke and Wheatstone telegraph had the economic disadvantage of requiring six wires between transmitter and receiver. This requirement raised the cost of their system over that of Morse's.

Samuel Morse learned enough about electricity on an ocean voyage from Europe to invent his telegraph. His

[1] Harold Sharlin is assistant professor, Department of Economics and History, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

device made use of the magnetic force of an electric current that had been discovered by Ampere and applied by Sturgeon. The magnetic force produced by a current from the transmitter forced a stylus down onto a piece of paper. The stylus caused indentations which were in the form of dots and dashes, a code invented by Morse. Morse's instrument required a trained operator but only two wires.

The history of the wiring of our continent is primarily an economic story. Science and engineering, unfortunately, played practically no part in this spectacular feat. Morse, his associates, and his competitors, were faced with the problem of making this new method of communication pay. There was considerable difficulty in raising enough money to pay for the stringing of the wires. The public, both individual and business, had to be coaxed into using the system. Lack of dependability was the chief complaint against the telegraph.

The New York to Boston line which was first strung in 1846 was an example of operating conditions of the time. The mechanical difficulties were only one aspect. After the first storm 170 breaks were reported over a distance of 30 miles. To avoid breaks, the copper wires had been strung with plenty of slack. The result was constant crossing of lines.[2] This difficulty was something a person with only rudimentary knowledge of electricity could have avoided.

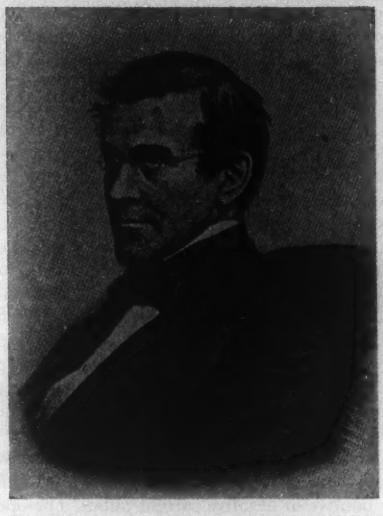
Pity the foreman on the New York-Boston line. "Yesterday I examined 59 posts and found the wires resting on the screws in 74 instances," he wrote in a report on one of the divisions. "They had not the appearance of having been drawn down by the weight of the wire, but were probably left so at the time they were put up. If there were no further difficulty, what I have discovered would be sufficient to account for failure to get the circuit through."[3]

RAPID SPREAD OF TELEGRAPHY

BUT ONCE AMERICANS SAW the usefulness of communication by telegraph to connect the rapidly expanding country, telegraph lines were strung at an astounding pace. By 1848, just 4 years after the first successful line from Baltimore to Washington (40 miles), 6,000 miles of wire were in operation. In 1852, 16,729 miles of wire were in operation out of a world-wide total of 23,275 miles.[4] One can only conclude that this feat was accomplished by some magnificent muddling through.

The British by the same year had only 4,000 miles of telegraph line in use. The English were making slow progress in the field of telegraph technology but the Americans, in spite of the impressive mileage record, had learned practically nothing. In 1867, the United States telegraph industry appealed to the British to send an engineer who was qualified to make a survey of the American lines with the object of recommending standards of voltage, current, and resistance for circuits and instruments. The man who came was C. F. Varley and he brought standards of operation up to those of England and the rest of Europe.[5]

The components of the telegraph system were simple



Sir Charles Wheatstone (1802-1875)

and few. There were the connecting wires, the motive power, and the instruments. One English engineer complained in 1852 that "the motive power, the widest field for substantial improvement, with very slight modification, has been left in its original expensive, unwieldy, and ineffective form."[6] Why was there neglect in this area? Because the improvement of the battery would have required more theoretical knowledge than any of the telegraph inventors had. The scientists, who could have done something, were not interested and there were no engineers trained for that kind of work.

English engineers were looking for a method of insulation which would be dependable and cheap. Cooke and Wheatstone had originally used cotton and shellac covering for their wires but the cost was a prohibitive 300 pounds sterling per mile. Suspending the wire on poles proved to be the best method. This method reduced the cost to one sixth of the original. Edwin Clark patented an insulating cap for attaching the wires to poles which completely overcame all difficulties "except those arising from fog."[7] Gutta percha was adopted by many in the hope that it would be a cheaper and more efficient insulator. It was too expensive to be used generally but it found wide use in subterranean and submarine cables.

INVENTIONS SPEED TELEGRAPH TRANSMISSION

THE MOST ATTENTION was paid to the telegraph instrument where, as one telegraph engineer said: "The inventive faculties appeared to be inexhaustible. . . ." But in this area there was no need for physicists or engineers for "in fact, any ingenuous clockmaker could produce modifications of them, and the ink on the receipt for the purchase of one would scarcely be dry, before another, perhaps better and cleverer, would be offered from the same fertile source."[8]

The object of all of this ingenuity was to increase the speed of telegraph transmission beyond the limit imposed by hand signaling of 150 letters per minute. One system invented by Wheatstone was called an automatic system because the transmitter was keyed by a strip of punched tape. Wheatstone also made use of double currents, that is, positive and negative pulses, and introduced series capacitance to reduce the inductive time lag on the instrument's magnetic coils.

David E. Hughes, a Kentucky teacher, invented a printing telegraph in 1855. Instead of the clockwork mechanism previously used, Hughes constructed instruments which had wheels that had to be kept in step. The transmitter resembled a piano keyboard with 28 keys. The message was printed on tape at the receiving end.

A. M. Baudot, an operator for the French Telegraph Administration, made use of his idle time between messages to invent an ingenuous and widely used telegraphy system. The system made use of a code invented by Gauss and Weber which consisted of five units of either positive or negative current pulses. The operator depressed five keys like a piano keyboard. The operator had to play in time with a cadence tapper. At the receiving end five currents were delivered to five electromagnets. Each electromagnet attracted an armature which pushed a rod which shifted a peculiarly shaped lever. Each letter of the alphabet corresponded to some combination of levers. The message was printed on tape at the rate of 150 letters per minute. The Baudot system was widely used in Europe.

Cooke and Wheatstone's 5-needle telegraph instrument (1837).

In the United States a system invented by Donald Murray was used by Western Union. The Murray machine was on the same general principle as the Baudot machine except that instead of using the cadence-timed transmitter it used a previously punched tape. Murray's receiver printed the message in page form.

Three telegraph systems were widely used throughout the world, namely, the Wheatstone automatic, the Hughes printer, and the Baudot printer.[9] Another method of making fuller use of the lines and increasing the number of messages which could be handled was by sending more than one message at a time. The first suggestion of duplexing was made by J. W. Gintl of Vienna in 1853. A really practical solution to the problem was found by a Bostonian in 1868.[10] The ultimate in the crowding of the wires was achieved by Edison with his invention of the quadraplex telegraph which sent two messages in each direction at the same time.[11]

PROBLEMS OF SUBMARINE TELEGRAPHY

THE EXTENSION OF A TELEGRAPHIC LINE across the Atlantic Ocean was at first assumed to be a simple extrapolation of the method of installing overland telegraph. As it was, most of the problems of the Atlantic Cable were mechanical and the electrical difficulties were solved with only a slight extension of theory.

Wheatstone had suggested before a committee of the House of Commons in 1840 that it was practicable to pass a submarine cable from Dover, England to Calais, France.[12] The first such cable was completed in 1851 but only after the discovery of gutta percha made it possible to protect cable from the sea water. The first Dover cable seemed to be a lucky chance because three successive attempts to repeat the laying failed. This cable was only 20 miles long. Gradually the length was increased; one to Holland was 115 miles, another across the Mediterranean was 110 miles. In 1855, a 350-mile cable was laid.[13] By this time men began to view the Atlantic as the next step.

Experience with cables much shorter than the projected 1,900-mile Atlantic cable convinced some that it would take too long to transmit messages that distance. In other words the Atlantic cable, according to some, was possible but would be unprofitable. A tranmission rate of about one word per minute was predicted.[14] Faraday suggested that the difference in rate of transmission between a suspended wire and a submerged wire was due to the Leyden jar effect of the action between the conductor and the surrounding water. But he estimated the time of transmission as 2 seconds.[15] William Thomson even reduced this estimate to four signals per second. Thomson's mathematics and experiments supported Faraday's intuitive views. In a paper before the Royal Society in 1856, Thomson had demonstrated the theoretical basis for the Atlantic cable:

> From these investigations it appeared, that without any direct trial on long subterranean, or submarine wires, but by reasoning on the known facts and measurements regarding electric conduction through copper, and electric induction across solid insulators, there were strong grounds for confidence, in expecting that a message of twenty words would not require more than seven minutes for its delivery. . . . There was even reason to think, that that rate might ultimately be exceeded. . . [16]

Preliminary investigations by the directors of the first Atlantic cable company arrived at the erroneous conclusion that "large coated wires used beneath the water, or the earth are worse conductors, so far as velocity of transmission is concerned, than small ones. . . ."[17]

The heretofore unnoticed property of electric wires which is now called inductive capacitance, Faraday's leyden jar effect, was the most difficult theoretical problem of the time. After the 1857 failure of the cable, an engineer wrote:

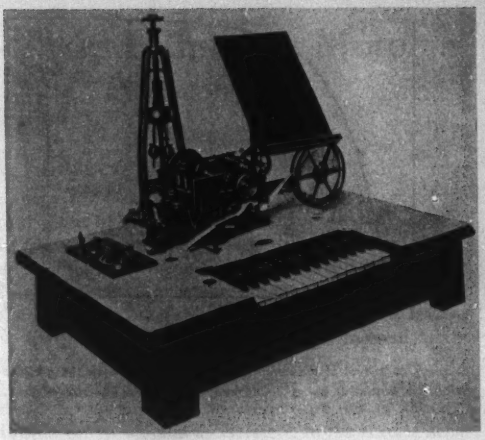
> There seems to be a great deal of uncertainty, in the minds of those engaged in applying electricity practically, regarding the laws of conduction and induction; and consequently the nature of the conductor which should be employed for long submarine circuits. [18]

The failure in the cable in 1858 was an electrical one. The break in communications was particularly disheartening because of all the gigantic physical difficulties involved in such a project. A generally accepted theory was that the insulation had failed, partly because of the abuse it sustained in manufacture, storage, and laying of the cable. Thomson believed that the failure was caused by impressing the extremely high voltage, for telegraph, of approximately 2,000 volts. The telegrapher who impressed such a high voltage had the popular misconception that the capacitance of the cable reduced the current in the cable. It does not. What the capacitance did was to cause the current of the telegraphic impulse to build up gradually instead of instantaneously as it would if there were only resistance present. To some the strange behavior of electric current in submarine cables seemed to reopen the question of the character of the electric fluid. The contrast between current in suspended telegraph wires and submerged ones, made many believe that they were dealing with entirely different kinds of electricity.

The more advanced theoreticians could not accept this view and could not believe as one wrote "that Nature, whose laws, science, as she progresses, invariably discovers to be simpler, and still more simple, should have one way of transmitting a current along one wire, another way of sending it along another. . . ."[19]

The speed of electricity through a cable was infinite. That is, there should be no delay between the transmission and reception of a current. Cromwell Varley wrote:

> The mistake, as to the non-instantaneous conduction of electricity has arisen from noticing only the arrival of the electric wave towards its maximum power, and not to its commencement. The apparatus used being only capable of recording when the wave had reached a considerable intensity, the first and weaker portions of the wave were not observed. . . . Electricity having neither momentum nor inertia, being incompressible into a conductor, and being capable of traveling through any length of line, must begin to flow out at one end, simultaneously with the application of the battery, at the other. [20]

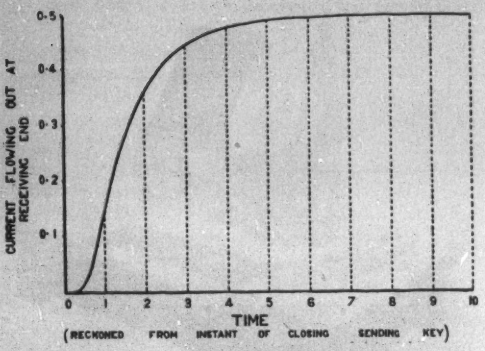


View of the Hughes-type printing telegraph showing piano-like keyboard.

William Thomson's galvanometer solved the last of the electrical problems connected with the Atlantic cable and all long-distance wire transmission. Actually Thomson's device sidestepped the problem of capacitance, but it was the simplest solution to a problem which presented difficult theoretical concepts for that time. His galvanometer was so much more sensitive than any other receiver to date that it reacted to the "first and weaker portions of the wave."

The Atlantic cable was successfully laid on the fifth attempt in 1866 but electrical engineering, the practical application of the science of electricity, had barely begun. The theoretical concepts on which the telegraph was based were developed by scientists like Ampere, Henry, Faraday, and William Thomson. The installation of a vast overland network of telegraph lines was accomplished by "clockmakers" and technicians unskilled in electricity. The result was clumsy, inefficient, and almost disastrous work.

Electrical theory on the other hand gained much from the experience of the telegraph. The most universal and significant concept to come out of telegraph work was that of capacitance. Yet there were scarcely any who realized its far-reaching importance. "Electricians" who were more and more called electrical engineers, still had to gain much of their knowledge the hard way, through failure. Ferranti, when he built his power cable from Deptford to London, was troubled at first by the capacitive effect of his concentric cables. He corrected the trouble by redesigning his cables. It took some time for engineers to recognize the similarity between capacitance in the direct currents of telegraph transmission and the capacitance which occurs in low-frequency telephone transmission. The theoretical and

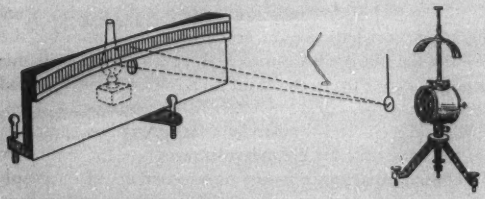


The curve of arrival of a submarine cable signal, showing the gradual rise of the current at the receiving end after certain intervals of time.

practical solution to the problem of capacitance in transmission lines was not solved until 1900 when Pupin demonstrated, mathematically and experimentally, the benefits of loading such lines with inductance.

GROWTH SPURS FORMATION OF SOCIETIES

ONE STAGE IN THE DEVELOPMENT of any profession is the formation of a society which provides the essential function of aiding the exchange of information. As we have seen, the telegraph at its outset was treated as a mechanical contrivance, and, logically, discussions on the telegraph were of interest to civil engineers. But there was so much else of importance that the telegraph received scant attention from this group. Papers and discussions on the telegraph were given before the Institution of Civil Engineers in England. All of the papers on this subject given between 1852 and 1865 fill only two thin volumes. These papers dealt largely with the nonelectrical problems. For example, the 1857-1859 session of the society had three papers dealing with the submarine telegraph. Two of the papers dealt with the problems of paying out the cable. The discussion on the papers each occupied four consecutive meetings. The papers and the discussion occupied 148 pages of the *Proceedings*. The third paper dealt completely with the electrical aspects of the cables. It was read in abstract and there was no discussion because, as the secretary of the Society explained in a footnote "of the number of evenings already devoted to the same subject."[21]



Kelvin (Thomson) mirror galvanometer for receiving signals through short submarine cables.

As Priestly had said, 70 years before, it was high time "to subdivide the business, that every man may have an opportunity of seeing everything that relates to his favorite pursuit. . . ."[22] The Society of Telegraph Engineers was established in 1872 for "the general advancement of Electrical and Telegraphic Science, and more particularly for facilitating the exchange of information and ideas among its Members."[23] The men who first formed the Society had misgivings because as the first president said:

> . . . shall we not degenerate thereby into "specialists," or what may be called "fractional quantities of scientific men," and this in face of the patent fact that the further we advance in scientific knowledge (whether pure or applied) the more clearly we perceive the intimate connection between its different branches, and the impossibility of cultivating one without constantly reverting to the others. . . . But our time is limited, and, although the great principles of nature may be understood generally by one person, their applications are infinite, and all we may hope to do is attain a general scientific basis, and with it to devote our energies vigorously to the details of one or two branches of applied science.[24]

There was really no need to fear overspecialization. The founders of the IEE and the AIEE acted at the moment just before electrical engineering spread across the whole field of modern technology. The years immediately following marked the beginning of the profession of electrical engineering.

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Switch Reversal of Single-Phase Induction Motor

A. K. DAS GUPTA

THE possibility of reversing single-phase squirrel cage induction motors simply by reversing the supply voltage at the terminals of the motor with a reversing switch has been investigated through experiments performed by the author and was found feasible. A very strong reversing torque was produced by reversing the voltage when the stator magnetizing current was near its maximum peak value. The motor was found to stop and reverse within 10 to 12 cycles.

According to the 2-reaction theory, reverse torque is produced due to interaction of the transformer flux ϕ_t along the tt axis (transformer axis), and current I_r along the rr axis perpendicular to the transformer axis, which current is produced due to the rotation of the rotor in the transformer flux ϕ_t. A flux ϕ_r is also produced along the rr axis which produces a forward torque due to interaction with the current I_t along the transformer axis.

In order to reverse the machine, the retarding torque should be increased and the forward torque reversed in order to create a very strong reversing torque. This stong reversing torque will stop the machine within a fraction of a second. If this retarding torque persists, the motor will accelerate in the reverse direction. These actions can be achieved by reversing the terminal supply voltage a few degrees earlier than the maximum point of the magnetizing current.

The reversing torque will gradually increase, starting with a low value, to maximum at about quarter periods after switching. This retarding torque, if strong enough, will stop the motor within a quarter of a cycle or slightly more than a quarter of a cycle beyond the switching point, and will accelerate it in the reverse direction.

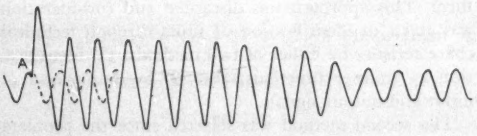

Fig. 1. Current wave of stator after reversal of terminal voltage.

A typical oscillogram of the current wave of the stator circuit due to reversal of supply voltage at the near point of maximum magnetizing current is shown in Fig. 1. Due to the saturation effect of iron, the inductance and time constant of the circuit is decreased. During the first cycle, the instantaneous reactance of the winding is practically its air core reactance, leading to a high rate of decay. The switch is reversed at the point "A." From the point of switching, up to a duration of nearly 225 degrees, the stator current, and thus the flux, remains positive. This duration is sufficient to stop the motor and accelerate it in the reverse direction.

Experiments were performed with single-phase fractional horsepower squirrel cage motors, starting windings of which were disconnected. One of the circuits followed is shown in Fig. 2. The switch blades were selected wide enough to short circuit the two terminals of the motor on their way to reverse the supply voltage connections. Because the switching was performed by hand, 25-cycle supply was selected for the test. It was observed that reversal by hand switching was extremely difficult for supply frequency above 50 cycles.

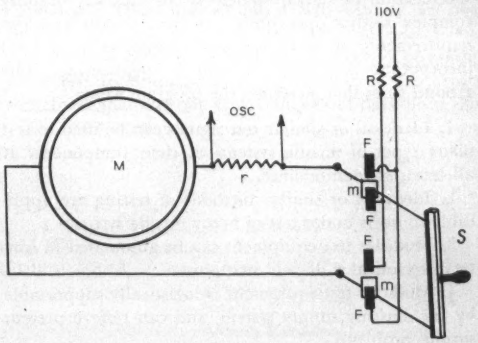

Fig. 2. Voltage reversing circuit. Osc.—oscilloscope; r—small shunt resistance for oscilloscope; S—switch; F—fixed contacts of switch; M—moving contacts of switch; R—current limiting resistance.

Where instantaneous stopping or reversal of a machine is desirable, and where the load inertia is not high enough to cause excessive mechanical stress, the method suggested here for instantaneous braking or quick reversal may be of great use. The maximum reversal time as observed, was nearly $\frac{3}{5}$ second. This method for normal 60-cycle motors will require further investigation. Repeated switching at proper phase angle may be one solution.

Digest of paper 60-772, "Possibility of Reversing Single Phase Squirrel Cage Induction Motors by Reversing the Terminal Supply Voltage," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 19-24, 1960. Published in AIEE *Power Apparatus and Systems*, Oct. 1960.

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Standardization of Electronic Test Equipment

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A discussion is presented of the principles, criteria, and techniques employed to carry out successfully an investigation into the practicability of multipurpose missile system test equipment. The prototype system subsequently built has demonstrated its operational flexibility, simplified testing procedures, and greater ease of maintenance.

SEVERAL years ago the Radio Corporation of America (RCA), at the direction of U. S. Army Ordnance, undertook a series of study and feasibility programs to standardize effectively ordnance missile-system test equipment. The purpose of the program was: (1) to eliminate unused capabilities and the overspecification of test-equipment accuracies, (2) simplify complex testing operations, (3) meet weight and size requirements of organizational maintenance, and (4) incorporate principles of human engineering. The ground rules that governed the program were:

1. Identical or similar test signals can be used to test many types of missile systems or their components at all levels of maintenance.
2. Identical or similar methods of testing are applicable to units under test of many missile systems.
3. Modular test equipment can be automated to conserve technical skills and manpower.
4. Modular test equipment is logistically supportable by the existing supply system, and can relieve present supply problems.

It appeared that the Nike-Ajax, the Corporal, the Lacrosse, the Hawk, and the wire-controlled Dart had little in common upon which to base a program for the standardization of test equipment. System studies were conducted to analyze the wide variations between missile systems in order to ascertain the validity of these premises: (1) that signals needed to test parts of system *A* could be used for a similar purpose with system *B*; (2) that basic similarities exist in methods of testing; and (3) that a minimum number of test-equipment modules could be used for the testing of each of these systems.

Proofs of the similarity of requirements of units under test (UUT) and the minimum number of test methods were established by a series of technical-characteristics and test-techniques studies. Test-equipment studies based on conventional test equipments provided the types of functional test circuits and their relative frequency of usage. An automatic testing study extended the test-equipment and test-technique studies to the present state of the art in automation, while a mechanical-standardization study was undertaken to arrive at a common incremental unit (or module) which affords modularized test equipment the ability to change by increments.

A logistics study provided the initial planning for the phasing of modularized test equipment into field usage.

UUT TECHNICAL CHARACTERISTICS STUDY

ORDNANCE MISSILE SYSTEMS have varying tactical missions, but when compared on the basis of subassembly functions they are quite similar. A detailed evaluation of the technical characteristics in terms of the input-output signal parameters of hundreds of UUT's provided the means for direct across-the-board comparisons and showed that signals to be generated and monitored by test equipment are common to most systems. To provide the basis for comparison of similarities and detection of important differences between UUT's, a method was evolved which described the major components and the subassemblies in terms of their input and output characteristics and power requirements.

Initially, an attempt was made to compare UUT's on the basis of their nomenclature. This approach proved impractical since two units identified as "modulators" had very little in common when it came to testing them. This approach was discarded and consideration was given to identification of units through technical characteristics by either of two methods: (1) identification by transfer functions; and (2) by delineation of input and output signals.

The second method was selected since the problem of determining transfer functions is much more complex than determining input and output signals and required information that was not available; also, the majority of testing on missile systems was of the open-loop rather than closed-loop type. In addition, test equipment is primarily required to generate and monitor test signals and not to test transfer functions.

The grouping of units from the missile systems by similarity of input and output characteristics resulted in the categorization of units with similar test equipment requirements. It was expected that if similar UUT's in the various systems required similar equipment and methods, then units from newer systems would also contain units with similar input-output

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characteristics that would be amenable to test by the same test equipments.

UUT categorization was accomplished by listing input and output characteristics described in terms of frequency, voltage or power, pulse width, wave-shape characteristics, etc. These characteristics were identified by a number or letter code (examples are: frequency, code *3*: 2 kc to 20 kc; waveshape characteristic, code *C*: FM). The coded information was entered on 5- by 8-inch punched cards together with information on the UUT by ordnance nomenclature and number and the manufacturer's test specifications and schematics. Each input and output was punched into a separate card; thus, a UUT with two inputs and three outputs would require five cards. A typical card is shown in Fig. 1.

For the first analysis, input-output characteristics were grouped by waveshape types as follows: (1) d-c constant, (2) d-c variable, (3) sine waveform, (4) peaked waveform, (5) rectangular waveform, (6) trapezoidal waveform, and (7) complex waveform. Determination of the density of signal types showed that sine waves predominated, constituting 37% and 32% of all inputs and outputs respectively; d-c signals were second, 27% and 25%. Rectangular, peaked, and complex waveforms each accounted for about 15%.

A definite correlation was found to exist across the missile systems studied. Further detailed examination revealed the areas of greatest density. For sine waves, density was heavy in the 250- to 400-cycle group, and in the 2- to 4-kc group. The 30- to 150-mc group also showed pre-eminence, although this was composed of discrete frequencies.

For the d-c input signals, the predominant grouping was in the 10- to 25-volt range. Relatively few input signals occurred at levels above 250 volts. Among output levels, the highest density was between 5 and 10 volts, with few outputs above 150 volts. Fig. 2 shows the frequency of d-c input voltage levels which is indicative of the type of information derived from this study.

Rectangular waveforms were compared in terms of their pulse width. Pulse widths in the 1.0- to 7.5-millisecond range predominated among the outputs, and 10 to 50 microseconds (μsec) pulse widths among the inputs. Peaked waveforms were also compared on the basis of their pulse widths. Among both inputs and outputs a heavy density of pulse widths existed between 0.25 and 1.3 μsec.

Predictions of the test technique applicable to a UUT based on its input or output characteristics were made. Certain signal types required the application of one or two test techniques; other signal types were found to have no discernible correlation. In general, sine waveforms either modulated, or in combination were more significant indicators of applicable test techniques than were d-c input-output signals. As an example, a UUT requiring a 60-mc pulsed input will usually be susceptible to gain- and frequency-response tests. The major source of error in making predictions of applicable test techniques based on a single input-output signal was that any one signal might not have been the

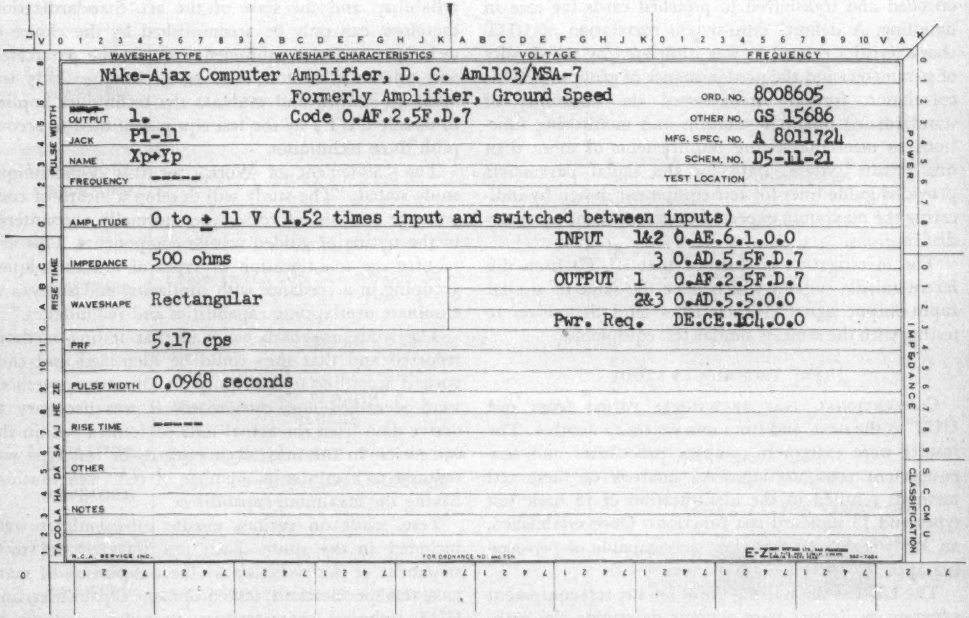


Fig. 1. UUT Technical characteristics card.

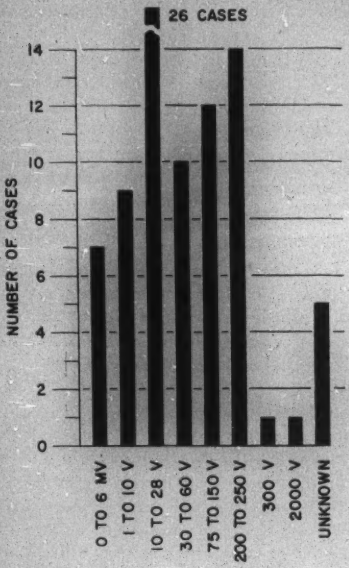


Fig. 2. *(left)* D-C input voltage requirements.

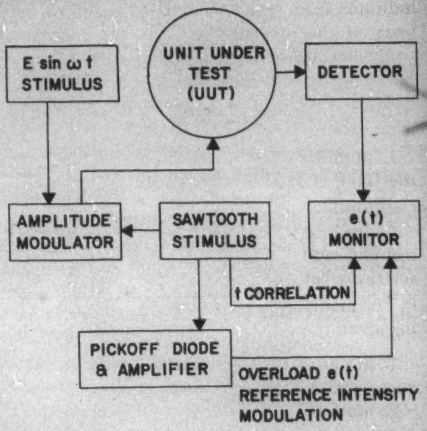


Fig. 3. *(right)* Overload test block diagram.

primary signal as far as the UUT function was concerned which explained the relative inability to predict on a basis of d-c signals.

In summary, the UUT characteristics study identified UUT's in terms of the technical characteristics of their input and output signals. These characteristics were encoded and transferred to punched cards for ease in handling. A definite cross-system correlation of UUT characteristics existed as was illustrated by the density of parameters and the predominance of groupings. This correlation further strengthened the feasibility of standardizing modular stimulus and monitoring functions to meet the testing requirements of more than one missile system. Data for the signal parameters provided guide lines for test equipment design by indicating the maximum expected extent, and any necessary distributions.

The investigation established that UUT's from different missile systems which have the same or similar input-output signal characteristics lend themselves to testing with the same or similar test equipment.

TEST TECHNIQUES STUDY

Conventional test techniques varied from one UUT to the next, and from one system to another. The results were extremely complex procedures and test-equipment configurations. An analysis of these test methods resulted in the identification of 18 basic test types and 13 standard test functions. Once established, an analysis showed that they were capable of performing approximately 85% of all tests.

The UUT is the starting point for any test-equipment program as its test requirements determine the capabilities of the test equipment. The test-equipment designer has relative freedom in selecting the testing technique and the specific circuitry to accomplish this. The elements to be considered in testing any equipment are: (1) the specific parameters, tolerances, and conditions of test which make up the test requirements, (2) the test technique or method of making the test, and (3) the test equipment required to accomplish the test. The parameters, measurement tolerances, and conditions of test are constants which are governed by the UUT, while the latter two elements represent the options of the test-equipment designer within the guidelines of adequacy, accuracy, simplicity, versatility, reliability, and the state of the art. Standardization, therefore, can only be accomplished by the choice of technique and test equipment to meet the parameters and tolerances of test. The test-technique study was made to analyze and evaluate the techniques applied to missile UUT's by the test equipment used to accomplish those techniques.

The "Statement of Work" for this test-technique study stated; "The study will develop a means of comparative analysis for techniques normally encountered in the testing of guided missile components. This will require the identification of types of test techniques, grouping in accordance with similarity, and analysis to eliminate overlapping capabilities and redundancy."

The study approach assumed that testing methods recurred and that they could be identified and categorized according to their purpose. Once these methods were identified and categorized, it was necessary to derive data from the actual tests performed within the categories. In this way, each category or test type was reduced to a minimum number of test configurations having the maximum capabilities.

Tests made on various missile subassemblies were included in the study. Each test was reduced to a statement of the essentials by the comparison of manuals, test specifications, test-equipment capabilities, and UUT technical characteristics, in order to eliminate procedural steps and to interpret test conditions and

indicator readings. The ideal result was a brief summary of the test, stating how it was performed, the parameters of the electric signals involved, and a block diagram of the test equipment.

Testing was considered as being divided into two major groups:

1. Monitor tests to appraise a single characteristic of the UUT at a specific point.

2. Monitor-stimulus correlation tests that injected a stimulus into the UUT, monitored the reaction to that stimulus, and required correlation of one or more characteristics between stimulus and monitor.

The monitor group was broken down into the following areas:

1. Monitor—passive: (a) voltage, (b) current, (c) frequency, (d) time, (e) waveshape analysis, and (f) noise.
2. Monitor—active: (a) resistance—continuity, (b) capacitance, and (c) impedance.

The monitor—stimulus correlation group was broken down into the following areas: (a) gain, (b) frequency response, (c) overload, (d) phase, (e) linearity, (f) waveshape, (g) time, (h) interaction, and (i) operational and adjustment.

Where a test type occurred in both the monitor and monitor-stimulus correlation group, the difference was the requirement for stimulus and correlation, both of which were inherent in the latter group.

A tabulation of the occurrence of test types revealed that the tests were almost equally divided into two major groups. Some of the more significant figures from the test type density investigation follow:

Test Type	*Total Test Analyzed (per cent)*
Monitor	
Resistance	10
Voltage	20
Monitor—Stimulus Correlation	
Gain	10
Frequency Response	10.5
Waveshape Analysis	8

The voltage monitor tests did not include the use of voltage monitors where they occurred as part of another test type, such as gain or overload. The voltage monitor usage of 20% represented minimum usage; the actual voltage monitor density considering all instances of its use was much higher. Based on this voltage and resistance, monitors were expected to accomplish 30% of all missile systems subassembly tests.

The techniques used for tests of a specific type were compared to reduce the number to a minimum and to choose a preferred technique where possible. The first criterion for such a choice was that the monitor and

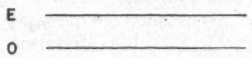
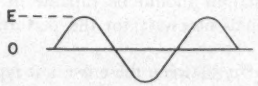
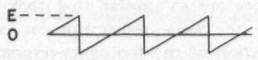
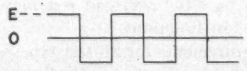
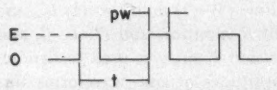
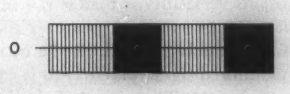
STIMULUS	FUNCTION	WAVEFORM
1. DC VOLTAGE	E_{dc}	
2. SINE WAVEFORM	$E \sin \omega t$	
3. SAWTOOTH WAVEFORM	$E(\sin X - 1/2 \sin 2X + 1/3 \sin 3X - 1/4 \sin 4X \text{-----})$	
4. SQUARE WAVEFORM	$E(\cos X - 1/3 \cos 3X + 1/5 \cos 5X \text{-----})$	
5. PULSE WAVEFORM	$E\left[k + \frac{2}{\pi}(\sin \pi k \cos X + 1/2\, k\pi \cos 2X + 1/3 \sin 3k\pi \cos 3X + \text{----})\right]$ WHERE $k = \frac{\text{PULSEWIDTH}}{\text{PERIOD}} < 0.1$	
6. AMPLITUDE MODULATED WAVEFORM	$E[1 + m_a F(t)]$ WHERE $F(t)$ IS ANY SPECIFIED STIMULUS FUNCTION	
7. FREQUENCY MODULATED WAVEFORM	$A \sin[wt + m_f F(t)]$ WHERE $F(t)$ IS ANY SPECIFIED STIMULUS FUNCTION	

Fig. 4. Stimuli input waveforms

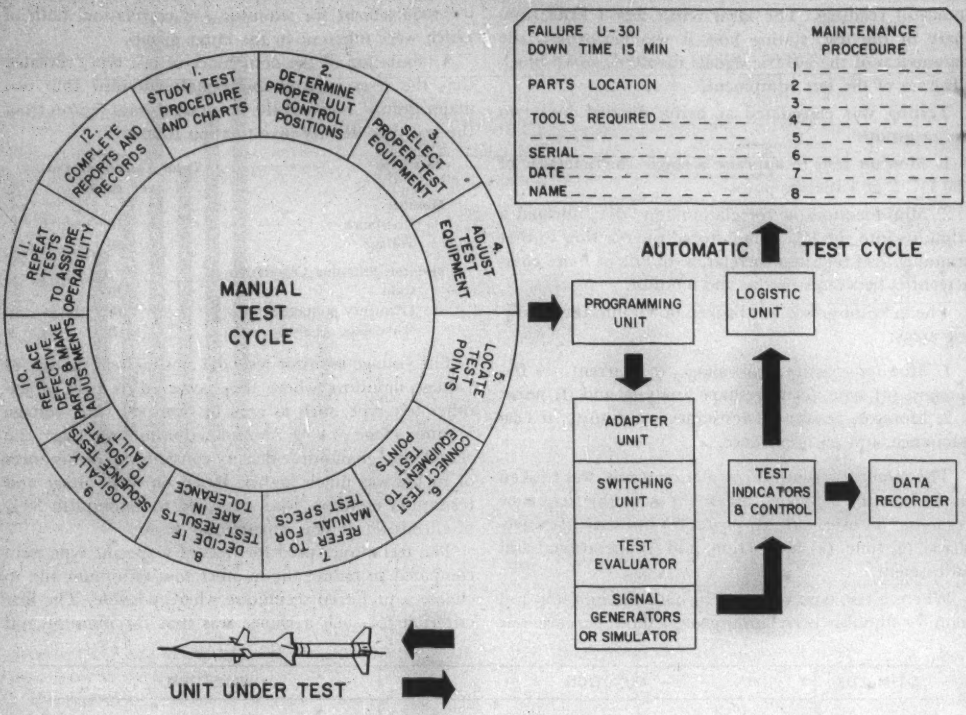


Fig. 5. Manual test cycle vs. automatic test cycle.

stimulus functions should be capable of the extreme ranges of signals necessary for the performance of the tests.

The similarity between these five test types suggested that similar methods could be applied to all. The last four test types are so similar that they can be performed with the same test-equipment configuration, using a variation of the frequency-response technique to simplify the operator's part in the test. Fig. 3 shows in block form how the overload test may be made in terms of basic test functions.

Monitor requirements for all test types were reduced to the following test functions: (1) $E_{d\text{-}c}$ monitor, (2) E sin ω monitor, (3) $e(t)$ monitor, (4) $I_{d\text{-}c}$ monitor, (5) T monitor, (6) R monitor, and (7) L, C, and Z monitor. (The expression E sin ω is used to denote monitors of voltage amplitudes of sine waveforms throughout the range of frequencies encountered. The notation $e(t)$ monitor is used to denote a monitor which permits measurement of voltage as a function of time.)

The outstanding example of the $e(t)$ monitor is the oscilloscope; its versatility is that it is a noninterpretative monitor. Unlike the a-c voltmeter that interprets all signals in terms of rms values, the oscilloscope displays the monitored signal precisely as it exists in terms of voltage and time. The virtue of noninterpretation can be a disadvantage in that the operator must translate the presentation in terms of the monitored parameters. Accessory functions such as voltage calibration, driven start-stop sweeps, time markers, and electronic switches simplify the translation problem.

The stimulus functions that would be required at the various frequencies, amplitudes, and time relations would have to be determined by a study of the individual UUT requirements. The specification of an E sin ω monitor should not be construed to mean that a single sine waveform monitor block is expected to cover the entire range of requirements but rather that the single function of sine waveform monitoring will be required. Variations of ranges and accuracies within the specified function are necessary and desirable. The stimuli requirements were reduced to the functions shown in Fig. 4.

In summary, testing can be considered as a series of individual tests assignable to categories by types. Monitors were reduced to seven basic functions capable of performing approximately 50% of all subassembly tests, and, with extended ranges, are required for monitor-stimulus-correlation tests. Stimuli generation functions were reduced to the minimum.

The specific techniques chosen could be considered as an optimum compromise and were termed standard techniques, so that the problem of meeting the test requirements of new UUT's could be simplified by

limiting the choice of techniques to those previously selected.

The selected test functions combined with the specific parameters required of input and output signals, made it possible to instrument test requirements for multiple applications.

TEST EQUIPMENT STUDY

An analysis of military and commercial test equipments confirmed that the circuits used differed widely from equipment to equipment. However, when these circuits were classified by function, 11 categories were established: (1) amplifiers, (2) attenuators, (3) detectors, (4) filters, (5) indicators, (6) modulators, (7) oscillators, (8) power supplies, (9) shapers, (10) waveform generators, and (11) miscellaneous.

Four circuit categories comprised over 50% of the total number of circuits. This permitted extensive standardization on the circuit level to be completed by routine methods on the basis of category.

AUTOMATIC TESTING STUDY

Automatic testers in use demonstrated that they could significantly reduce the time required for testing. That automation could be incorporated into a test system was demonstrated by test sets built during this phase of the program to demonstrate that functional modular standardization of circuits and modules was practicable and possible.

Manual functions together with test systems components to perform these automatically are shown in Fig. 5. An automatic test system consists of five basic functions: (1) programming equipment to provide control; (2) switching unit to route signals; (3) test evaluator to determine the test results; (4) adapters to link the test system and the UUT; and (5) stimuli to provide signals for the UUT.

Table I. Stimuli Requirements for Five Test Types

Test Type	Frequency	Stimuli Freq. Range	Amplitude	Amplitude Range
Frequency Response	Variable	Above and below UUT bandpass	Constant	
Overload	Constant, usually center frequency of UUT bandpass		Variable	To above UUT overload point
Sensitivity	Constant, usually center frequency of UUT bandpass		Variable	To below UUT min. discernible signal
Linearity	Constant, usually f_c		Variable	From min. discernible signal to overload point
Gain	Constant usually f_c		Constant	

Selection of one type of function is determined by accuracy, environmental conditions, characteristics of the UUT, and whether the test is for operability or fault isolation. Equally important and interdependent with the selection of function is selection of the test method. Static testing (point-to-point tests made without signal stimulus), permits continuity, leakage, impedance, resistance, transformer ratios, and point-to-point voltage tests, but does not measure frequency response, power outputs, noise, detect oscillator drift, intermittent operation, et al.

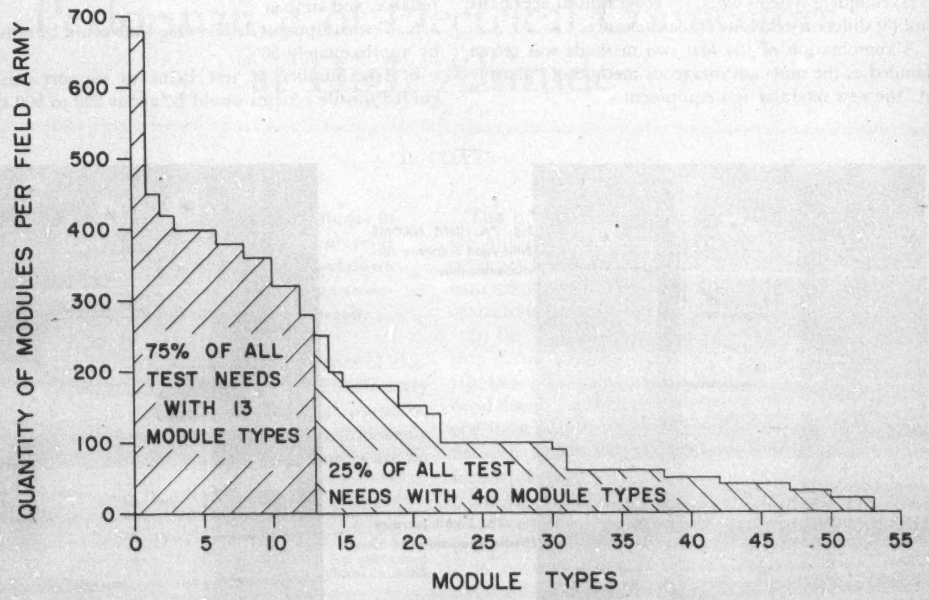


Fig. 6: Distribution of standardized test equipment modules for field army.

Dynamic testing is performed on energized equipment with stimuli applied. This may be open-loop (a fixed signal is applied and a measurement is made of the UUT reaction), or closed-loop (the input stimulus is dynamically varied as a result of feedback). An exhaustive analysis of all types of automatic test equipment was made and the results utilized during the development of specifications for an ordnance test system.

LOGISTICS STUDY

EARLY IN THE PROGRAM it was seen that the problems of supply, maintenance, and training were interrelated with test equipment capabilities. Equipment quantities and type would have to be derived before a complete testing plan could be made. Translating modular test equipment requirements to an assumed field-army basis revealed that 53 different types of test equipment modules would be required for six missile systems. Of the total of 53 module types, 13 constituted 75% of the requirements. (Fig. 6).

There are difficulties in introducing any new type of equipment into the field. The transition affects the elements of supply, maintenance, and training. Each of these elements has a different lead time and each is dependent on the others at various points. All are dependent upon production and documentation, which, in turn, have their own partially interdependent lead times. Co-ordination of all of these lead times is the major problem to be solved during the introduction of new equipment into an existing logistical system.

Three methods of introducing standardized test equipment were considered:

(1) complete systems basis; (2) geographical area basis; and (3) different echelons of maintenance.

A combination of the first two methods was recommended as the most advantageous method of "phasing-in" the new modular test equipment.

CONCLUSIONS DRAWN FROM THE STUDIES

IT WAS ESTABLISHED CONCLUSIVELY that the modular concept of test assemblies in the form of standard building blocks could be developed for test equipment purposes. The modular concept was not limited to general-purpose test equipment items, but also applied to special-purpose test equipment.

The advantages of assembling special-purpose test equipment from standard on-the-shelf modules were proven. The basic premise of subequipment level standardization was validated. Test assemblies developed from the standard modules simplified operation, reduced control and indicators, was selfcalibrating and monitoring, and utilized automatic testing techniques.

The anticipated elimination of unused capabilities as predicted during the investigation was proved. The NAOME (Nike-Ajax ordnance missile evaluator) was one-third the size of the depot equipment whose function it replaced, and the modularized Lacrosse Autopilot tester closely corresponded to the weight and size of the conventional first and second echelon testers now used for this missile (Fig. 7).

Other conclusions were:

1. Efficient specialized test assemblies could be constructed from standard electronic test equipment developed in accordance with the criteria and techniques determined during the study phases.

2. Test assemblies would possess minimum complexity and maximum expansion capabilities.

3. Modular test assemblies would achieve a weight and size reduction of from 30% to 50% over existing equipment.

4. Modular test assemblies would be cheaper, more reliable, and simpler.

5. Test equipment delivery lag time could be reduced by approximately 50%.

6. The number of test items to support existing guided missile systems would be about 200 to 300 mod-

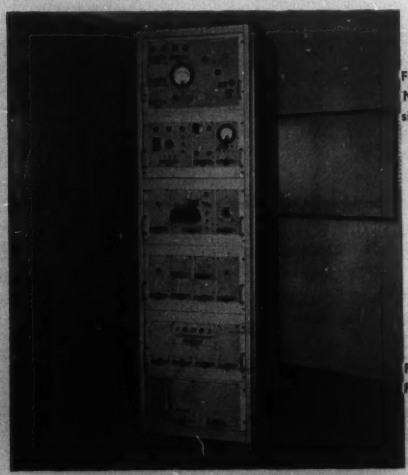


Fig. 7A. (left) NAOME Nike-Ajax ordnance missile evaluator.

Fig. 7B. (right) Lacrosse Missile Evaluator.

ular types which represents an equipment reduction of approximately 65% from that presently used.

7. Modular test assemblies are compatible with manual, semiautomatic, or fully automatic operation.

8. The operational simplicity of testers developed during the program would permit more effective maintenance with fewer personnel of lower skill and less training.

9. Modularization would permit immediate introduction of transistorized circuits.

RESULTS BASED ON THE STUDIES

AT THE CONCLUSION of the study program, U. S. Army Ordnance and RCA recognized that the full advantages of Ordnance Corps guided missile test-equipment standardization were feasible, and that the areas of standardization could be extended from the building block itself to its functional application, associated test techniques, and the basic circuit in each building block. In addition, the scope of the project should be expanded to assure that all requirements imposed by new and/or different missile systems are met. It was further recommended that: (1) The principles, criteria, and techniques developed to date be applied to ordnance-guided missile electronic test equipment; (2) Other missile systems be included for application of standard modular test assemblies; and (3) The manufacturer should clearly specify the individual UUT test requirements for each level of maintenance.

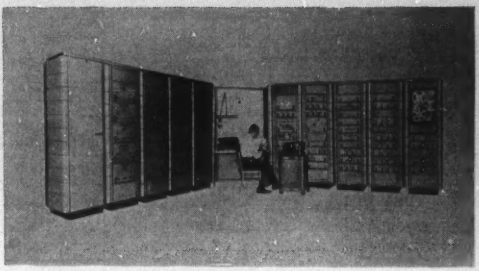


Fig. 8. DEE (digital evaluation equipment) engineering model in operation.

Based on these findings, the U. S. Army Ordnance extended RCA's contract to build and demonstrate a multipurpose missile-system test equipment which would mechanize the recommendations made during the study and feasibility phases. This equipment, named DEE (Digital Evaluation Equipment), was built and successfully demonstrated to Army Ordnance on December 17-18, 1959. (Fig. 8).

UUT's from six missile systems were tested by the equipment both statically and dynamically, thus proving conclusively that test equipments for missile systems could be standardized and integrated into one automatic test system.

Performance of Electrical Connectors at High Altitude

A. L. COATS

Operation of electrical connectors at altitudes in the range of 100,000 to 200,000 feet presents special problems insofar as electrical breakdown is concerned. Test criteria and means for achieving improved performance are discussed.

IN RECENT YEARS, studies of performance of electrical connectors at altitudes up to approximately 65,000 feet have been sufficient for most purposes. However, because of the extreme altitude requirements of present flight vehicles, data from these studies are no longer adequate.

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The problems of obtaining reliable information in the altitude ranges in which we are presently interested are much more difficult to solve, as are the problems of trying to improve the existing performance characteristics at these altitudes.

In the range from sea level to 65,000 feet, the pressure drops from 760 mm Hg to approximately 42 mm Hg. It is not difficult to make observations of electrical breakdown sparkover and corona and to distinguish one from another in this range of pressures. However, between 65,000 and 300,000 feet, the pressure drops from approximately 42 mm Hg to approximately 5 microns Hg. For the geometry involved in electrical connectors, this pressure change encompasses a critical point in electrical performance.

MINIMUM SPARKING VOLTAGE

IT HAS LONG BEEN established that all gases have a

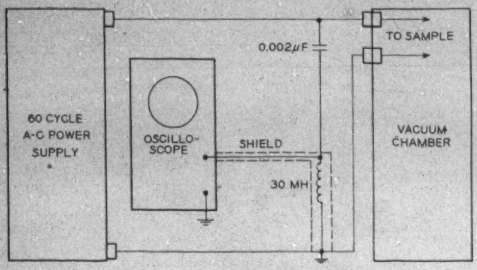

Fig. 1. Corona-detection circuit.

minimum sparking voltage below which a spark cannot occur, regardless of density or spacing of the gap. This is in accordance with Paschen's law which, simply stated, says that the sparkover voltage between electrodes is a function of the density and the length of the gap separating the electrodes. As this product is decreased, the sparkover voltage between electrodes is decreased until the minimum sparking voltage is reached. Further decreases in the product result in increases in the sparkover voltage.

A widely quoted theoretical value for this minimum sparking voltage for air is 346 volts for uniform fields. Competent authorities state that 275 volts is an absolute minimum voltage below which sparkover cannot occur in air under any circumstances.[1]

With the type of terminations involved in electrical connectors and the termination spacings applicable, this minimum sparking voltage is encountered in the range of 100,000 to 200,000 feet. The value of the minimum sparking voltage observed is approximately the same, independent of the contact spacing in the range of spacings applicable. Changes in contact spacing change the density at which the minimum sparking voltage is observed but do not significantly change its value.

Further decreases in density result in a rise in sparkover voltage which, if followed to the extreme, results in sparkover voltages many times greater than those found at sea-level pressures. This phenomenon has resulted in the development of high-vacuum devices wherein dielectric strengths up to 5,000 volts per mil are obtained.

This phenomenon also looks very inviting to the designer of circuits for vehicles operating at altitudes where this effect can be utilized. The effects of intense radiation and other ambient conditions existing in space on these electrical performance characteristics are not generally known and are beyond the scope of this article. Assuming, however, that good electrical performance can be obtained in the extreme low-density areas of outer space, it is still necessary to pass through the very critical area between 100,000 and 200,000 feet to attain this region. Telemetering circuits and other control circuits must function while passing through this critical range.

TEST CRITERIA

At sea-level pressures and up to approximately 65,000 feet, data on sparkover voltages and corona are easy to obtain and the criteria for breakdown are not difficult to establish. However, as the minimum sparking potential is approached, this criterion for sparkover becomes increasingly difficult to establish. It is very difficult, and possibly not practical, to try to distinguish between corona and sparkover, as the characteristics of these phenomena are greatly changed from those at higher densities. Corona discharges at each electrode gradually appear and gradually grow larger as voltages are increased until the glow encompasses both electrodes.

To set a criterion of the first incidence of corona, or for the extinction of corona, requires a definition of the corona-detection device, as the sensitivity of the detection device then becomes the controlling factor. A visual criterion may be established. If the work is done in a dark room, discharges can be readily observed and a criterion of first visual appearance of discharge can be called breakdown. This appears to be a practical level at which to set the criterion but may not always be practical for other reasons. A simple corona-detection circuit with a sensitivity roughly corresponding to this visual level is perhaps a more practical tool. Such a circuit has been used by various

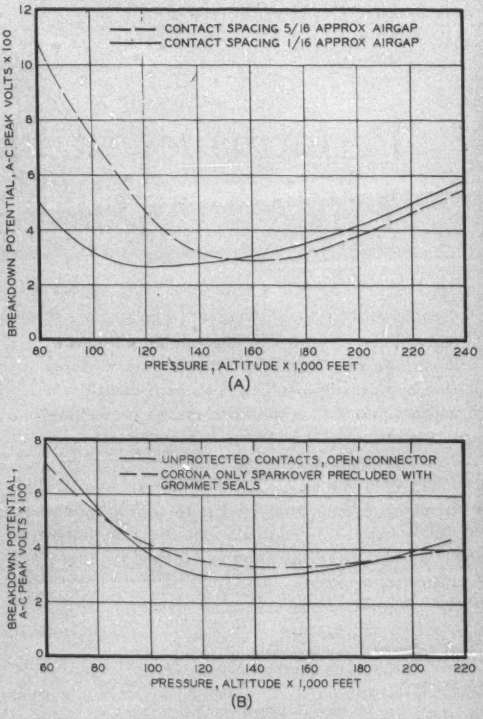

Fig. 2. Breakdown voltage vs. altitude.

groups and has provided useful information and good correlation among different laboratory groups. Fig. 1 illustrates such a circuit.

As the lower densities are reached and the minimum sparking potential region is passed, the characteristics of the discharge gradually change until corona and sparkover can again be separately recognized as more closely resembling the characteristics observed at sea-level operation.

Fig. 2 (A) illustrates data obtained on two electrical connectors of widely different contact spacing through this critical range. These samples represent approximately the maximum and minimum spacings practical in electrical connectors, and illustrate the fact that improved performance in this critical range cannot be solved by providing wider spacing between contacts. A visual observation in a dark room was the breakdown criterion used for this data.

IMPROVING PERFORMANCE

THE OBVIOUS SOLUTION to the problem of improving performance in this region is to imbed the terminals in potting compound or in resilient grommets to provide continuous insulation, thus preventing sparkover. This also requires a seal at the mating joint of the connector.

This approach is being used in many applications. However, most present designs are not sufficiently reliable for use in carrying higher voltages than those that can be carried on an open connector; rather they serve to provide moistureproofing and freedom from contamination. A very high degree of reliability of sealing is required if voltages above those that can be demonstrated on open connectors are to be used.

If it is assumed that this approach, in improved form, will reliably prevent actual sparkover, the voltage rating of the connectors often cannot be increased because corona will continue to be a severe problem.

Fig. 2(B) illustrates this condition. It shows that on an imbedded connector corona can occur at a voltage approximately the same as that at which breakdown occurred on the same connector with unprotected terminations. Visual observation in a dark room furnished the criterion for this data.

The point at which the wires enter the metal shell of the connector is a particular stress point and corona will occur there first. A similar condition, however, will exist any place along the wires where they are adjacent to a ground surface. Simple shielding of the cables will not materially improve this condition. To be effective, the shield must be so installed that no air at reduced density can exist between shield and cable insulation.

A technique for handling this condition successfully has been worked out. It calls for a harness assembly with a gas-tight outer sheath sealed to all connectors. The shields are carried inside this sheath and so terminated at the connector shells that no particular stress points exist. In the potting of the contact terminations, extreme care must be taken that no air bubbles exist in the compound, as they will be subject to corona. A special connector was designed to provide a reliable

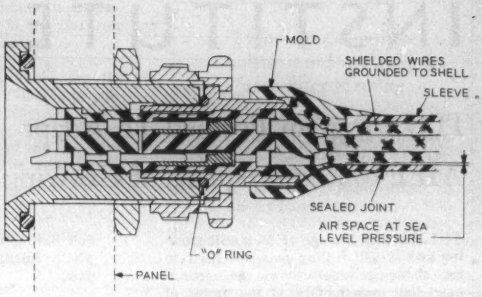

Fig. 3. Corona-resistant connector and cable assembly.

main-joint seal with the shell components. An end interference seal of resilient dielectric insulators alone will not provide corona-free operation. All internal parts of the connector must be maintained at normal air density to control corona discharges.

Fig. 3 illustrates the design concept of this approach. This type of harness-and-connector combination will provide corona-free operation at critical altitudes of voltages in excess of those that could normally be employed. Laboratory models of this type have been found to be corona-free throughout this critical altitude range, with voltages as high as 1,000 volts rms a-c. The corona detection circuit of Fig. 1 was used for this work. Visual observation under these conditions is not satisfactory.

Due to the extreme care required in manufacturing, however, this performance level is difficult to maintain reliably. With present techniques, voltages above 800 volts rms should not be planned for this approach.

CONCLUSIONS

IN THE ALTITUDE RANGE of 100,000 to 200,000 feet, a critical pressure is reached at which air gaps between wire terminations in connectors exhibit their poorest electrical breakdown characteristics. Circuits that must operate in this range in unpressurized areas can be expected to experience breakdown at voltages less than 300 volts peak unless special provisions are made.

Applying a normal safety factor, it would be well to limit operating voltage on unprotected connectors in these areas to approximately 150 volts peak.

Elimination of sparkover presents, theoretically, a relatively simple problem, but practically it is very difficult to achieve with sufficient reliability for good engineering practice.

Elimination of corona is more difficult than elimination of sparkover, but it may be accomplished with special handling of circuits.

The effects of solar and cosmic radiation and other high-altitude ambient conditions must be studied. Such studies, to be most useful, should be made on complete wiring systems installed as in service.

REFERENCE

1. Fundamental Processes of Electrical Discharge in Gases (book), L. B. Loeb. John Wiley & Sons, Inc., New York, N.Y., 1939, chap. 10, p. 413.

INSTITUTE ACTIVITIES

ITG Program Formed To Adapt AIEE to Requirements of Growing Membership

THE AIEE at the age of 75 is still growing and is still willing to adapt itself to the changing requirements that accompany that growth. One of the means of strengthening the Institute while accommodating recent growth is the program of Institute Technical Groups (ITG's), authorized as a result of the recent specific suggestion of the Special Task Force on Institute Activities and Organization, headed by Prof. W. A. Lewis.

In accordance therewith, the Technical Operations Department (TOD) appointed an Ad Hoc Committee on Institute Technical Groups, which, under the chairmanship of P. K. McElroy, has formulated its initial plans, as here set forth.

There are a number of developments with which the formation of ITG's is expected to deal helpfully:

1. The very large, if not unwieldy, membership of the Institute.

2. The rapid growth of specialties within the electrical engineering profession which has inevitably resulted from the mushrooming developments in the technical areas covered. Many of the specialties now have as many adherents as the whole Institute did in its early days.

3. Practitioners of the various specialties, and particularly the younger engineers just entering upon their professional lives, are anxious to have a real voice in the conduct of the programs in their specialties. Decentralization of control is necessary.

4. There is a need for lists of members interested in various Institute specialties. For instance, members in charge of managing Special Technical Conferences have no AIEE clientele to form the basis for a productive mailing list. Many other societies are divided by areas of interest, e.g., the American Society for Quality Control and its various divisions, electronic, chemical, etc.

5. The basic reason for AIEE's existence is the dissemination of technical information. Thus, each member should be informed in print as part of his membership benefits. On the other hand, it is wasteful to supply him with papers in fields too remote from his interest. A publication for each of the ITG's could help provide a solution.

How

Broadly, an Institute Technical Group should be founded only when there is a true, continuing, viable demand for the services it can give. Once this is demonstrated, the ITG will be encouraged to establish itself, grow, and operate with an absolute minimum of restraints. It will be able to choose its field of interest, its associates, and its program in a way that will best advance its technical purposes. The only restraints will be those necessary to assure amity and consistency within AIEE. The Institute Technical Groups Co-ordinating Committee, responsible to the Board of Directors through TOD, will be a continuing channel for the guidance of ITG's as a whole.

Here are a few criteria for ITG's as entities:

1. The first and simplest concept is that some ITG's would be originally formed as appendants to existing Technical Committees. It is neither expected nor hoped that all of the 50-odd Committees* now extant would attract ITG's to themselves, for such a structure would be unwieldy.

2. If, as just indicated, some Committees do not have appendant ITG's, there will be other potential ITG's which have no Committees to which to attach themselves. This may suggest any one of several courses of action. If there is a Subcommittee covering the technical field involved, perhaps the Subcommittee should be elevated to Committee status, at which time it could make a home for the ITG. If there is not even a Subcommittee in existence, a host Committee in the field of interest might be formed through the cognizant Division or the New Technical Activities Committee.

3. When a proposed ITG has a scope that involves more than one existing Committee, the Committee structure and scopes may be re-

*The names of Technical Committees and their Chairmen are listed in *Electrical Engineering* for September 1960, pp. 784-85, in the Organization Manual, etc.

I would like to be a member of an ITG sponsored by the

Committee on _____

I propose an ITG to be called _____

_____

to cover technical matters as follows: _____

_____

_____

_____

_____

(Send no money) **Signed** _____

(Please Print) **Address** _____

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arranged to provide a single proper Committee for the ITG.

4. To initiate a *proposed* ITG, 50 applicants of any grade are required. A contact man or sponsor will be appointed, suitable publicity will be given, and other AIEE members interested will be invited to join.

5. When the proposed ITG has sufficient people interested they will be invited to pay dues. When there are 250 paid-up members, the ITG will become permanent, i.e., it will be the dominant entity rather than an appendage. It will establish its own bylaws and will have its own Committee as part of the Division. It may elect its own officers, conduct its own programs, etc.

Formation

It is important that there be a real grass-roots desire for any particular ITG, or it may not last. Any group of members may apply to Headquarters for the formation of an ITG with a particular scope in which they are interested. When enough have applied, steps will be taken to form the ITG.

Such groups may be stimulated to apply by:

1. Their own strong technical interest in a particular field.

2. An existing Technical Committee which feels that the people interested in its field will desire an ITG.

3. Publicity at General Meetings, in *Electrical Engineering*, or by direct mail solicitation.

If a member desires to start such an ITG, he may

(a) Send in on the accompanying coupon the name of an existing Committee that he feels should have an ITG attached to it and that he would like to join if it is formed.

(b) Get together with friends and send in a scope and a name for an ITG that he would like to join.

Functions

When an ITG has been formed it will, by means of its Committee:

1. Conduct the administration of the ITG as an organization for its members' technical benefit.

2. Plan and sponsor Technical Sessions at General and other Institute meetings. This includes soliciting and reviewing papers, arranging for special speakers, planning trips, and visits, etc.

3. Plan and sponsor Special Technical Conferences, either by itself or in co-operation with other ITG's or with other societies, such as Professional Groups in the Institute of Radio Engineers, etc.

4. Co-ordinate publications for the ITG, prepare news items and publicity, etc.

5. Outline the scope of the ITG, prepare suitable bylaws, and co-ordinate with other ITG's and Committees.

6. If desired, elect its own officers.

Sections

Relations between Sections and the AIEE will suffer a minimum of changes:

1. The members of ITG's in a given area may form local Chapter Groups. These Chapters should be affiliated with and co-ordinate their activities with their Sections, as agreed upon locally. In such cases, the Section will help with financing (with AIEE assistance), scheduling meetings, and other such matters.

2. In many regions, the members of any one ITG may be too few to justify separate local meetings. In such cases, local members of several ITG's may combine to form local Groups, say along Division lines, as a part of the local Section. (Such Groups have already been formed in certain Sections). This will not affect their memberships in Institute Technical Groups.

3. Each local Chapter Group will have freedom to advance, to the best of their abilities, their chosen fields of technical interest in the various geographic areas.

4. Each local Chapter Group may have its own representatives or officers.

5. In some cases, ITG's in adjacent Sections may combine to sponsor technical meetings in their own particular field.

Publications

The publication policy will be to allow whatever each ITG wants and can afford, and only experience will determine what will be the most appealing. At the start, the arrangements will be:

1. *Electrical Engineering*, the Bimonthlies, and *Transactions* will not be appreciably changed at present.

2. Each ITG will issue its own publication, including selected topical technical papers, reports on committee activities and standards work, and other news of interest to the membership. The technical papers may include the better ones of conference papers, District papers, or special technical conference papers, and perhaps an occasional Transactions paper. This is not believed to be the ultimate ideal and may be adapted as experience suggests.

3. Each ITG will co-operate in the publication of reports of Special Technical Conferences it sponsors singly or co-operatively.

Dues

Suitable dues set up by each permanent ITG will be paid yearly to Headquarters by each member. This money will be segregated and a detailed statement of expenditures and funds on hand will be issued each year. However, $1 of such dues per year per member will be paid into the AIEE general funds for clerical and editorial help and other general expenses connected with ITG's.

Other expenses to be paid out of the other ITG funds will include specific printing and mailing costs, special meeting expenses, and other expenses the ITG incurs by their own requests.

It is expected that dues of permanent ITG's will generally be about $4 per year, though they may be more or less as determined by the ITG. Each ITG must avoid deficits by raising the dues or reducing the expenditures.

Technical Committee Chairmen to Hold Forum at Winter Meeting

The usual meeting of the Forum of Technical Committee Chairmen will be held in connection with the Winter General Meeting, New York, N. Y., in the Georgian Room of the Statler-Hilton Hotel from 7:30 p.m. to 10:00 p.m., Wednesday, February 1, 1961. An invitation to attend is extended to anyone concerned with the administration of the Technical Operations Department. Among the topics to be considered are: Rotating Sessions assignments of Technical Committees at General Meetings: and Application of Technical Papers Controls by the Divisions.

Other topics of interest may be introduced. It is to be assumed that recent experiences will be discussed in connection with the reporter system of conducting meetings; with Institute Technical Groups; and with new technical activities.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N.Y.

AIEE Future Meetings

Defense Dept.-AIEE-ARS-ANS-IRE-ES-ASHRAE-AIME Thermoelectric Energy Conversion Conference*
Statler-Hilton Hotel
Dallas, Texas
January 8-12, 1961

AIEE-IRE-ASQC-EIA Reliability & Quality Control Conference*
Bellevue-Stratford Hotel
January 9-11, 1961

Winter General Meeting*
Hotel Statler
New York, N. Y.
January 29-February 3, 1961

AIEE-IRE-U of P International Solid-State Circuits Conference*
University of Pennsylvania
Philadelphia, Pa.
February 15-17, 1961

AIEE-IAS-IRE-U of P Engineering Aspects of Magnetohydrodynamics Symposium
University of Pennsylvania
Philadelphia, Pa.
March 9-10, 1961
(Final date for †TP—closed, ‡CP Syn.—closed. CPMs—Jan. 3)

South East District Meeting
Jung Hotel
New Orleans, La.
April 5-7, 1961
(Final date for †TP—Jan. 5, CPMs —Jan. 30)

Rubber and Plastics Industries Conference
Sheraton Hotel
Akron, Ohio
April 10-11, 1961
(Final date for †TP—Jan. 10, ‡CP Syn.—Jan. 24, CPMs—Feb. 3)

Materials Handling Conference[1]
Pick-Congress Hotel
Chicago, Ill.
April 11-12, 1961
(Final date for †TP—Jan. 11, ‡CP Syn.—Jan. 26, CPMs—Feb. 6)

Electric Heating Conference[1]
Sheraton-Lincoln Hotel
Indianapolis, Ind.
April 11-12, 1961
(Final date for †TP—Jan. 11, ‡CP Syn.—Jan. 26, CPMs—Feb. 6)

Extra High Voltage Cable Conference[1]
Mark Twain Hotel
Elmira, N. Y.
April 11-13, 1961
(Final date for †TP—Jan. 11, ‡CP Syn.—Jan. 26, CPMs—Feb. 6)

Cement Industry Conference
Sheraton-Cadillac Hotel
Detroit, Mich.
April 18-20, 1961
(Final date for †TP—Jan. 18, ‡CP Syn.—Feb. 2, CPMs—Feb. 13)

Great Lakes District Meeting
Hotel Pick-Nicolett
Minneapolis, Minn.
April 19-21, 1961
(Final date for †TP—Jan. 19, CPMs —Feb. 13)

AIEE-ASME Railroad Conference
Sir Francis Drake Hotel
San Francisco, Calif.
April 20-21, 1961
(Final date for †TP—Jan. 20, ‡CP Syn.—Feb. 3, CPMs—Feb. 14)

Joint Rural Electrification and Appliance Conference
Kentucky Hotel
Louisville, Ky.
May 1-3, 1961
(Final date for †TP—Jan. 31, ‡CP Syn.—Feb. 15, CPMs—Feb. 24)

AIEE-IRE-EIA-WCEMA Electronic Components Conference
Jack Tar Hotel
San Francisco, Calif.
May 2-4, 1961
(Final date for †TP—Feb. 2, ‡CP Syn.—Feb. 16, CPMs—Feb. 26)

Spring Textile Conference
Heart of Atlanta Motel
Atlanta, Ga.
May 4-5, 1961
(Final date for †TP—Feb. 3, ‡CP Syn.—Feb. 17, CPMs—Feb. 28)

AIEE-IRE-ACM Western Joint Computer Conference
Ambassador Hotel
Los Angeles, Calif.
May 9-11, 1961
(Final date for †TP—Feb. 8, ‡CP Syn.—Feb. 23, CPMs—Mar. 6)

Packaging Industry Conference
New Ocean House
Swampscott, Mass.
May 15-16, 1961
(Final date for †TP—Feb. 14, ‡CP Syn.—Feb. 28, CPMs—Mar. 10)

North Eastern District Meeting
Statler Hotel
Hartford, Conn.
May 17-19, 1961
(Final date for †TP—Feb. 16, CPMs —Mar. 13)

AIEE-IRE Globe-Communication V Conference[2]
Chicago, Ill.
May 22-24, 1961
(Final date for †TP—Feb. 21, ‡CP Syn.—Mar. 8, CPMs—Mar. 17)

AIEE-IRE-ISA-IAS-ARS National Telemetering Conference[2]
Sheraton Towers
Chicago, Ill.
May 22-24, 1961
(Final date for †TP—Feb. 21, ‡CP Syn.—Mar. 8, CPMs—Mar. 17)

Fractional Horsepower Motors Conference
Biltmore Hotel
Dayton, Ohio
May 23, 1961
(Final date for †TP—Feb. 22, ‡CP Syn.—Mar. 9, CPMs—Mar. 20)

Summer General Meeting
Cornell University
Ithaca, N. Y.
June 18-23, 1961
(Final date for †TP—Mar. 20, ‡CP Syn.—Mar. 30, CPMs—Apr. 14)

Pulp and Paper Conference
Kalamazoo, Mich.
June 21-23, 1961
(Final date for †TP—Mar. 23, ‡CP Syn.—Apr. 7, CPMs—Apr. 17)

Aero-Space Transportation Conference
Benjamin Franklin Hotel
Philadelphia, Pa.
June 26-30, 1961
(Final date for †TP—Mar. 28, ‡CP Syn.—Apr. 12, CPMs—Apr. 21)

AIEE-AIChE-ASME-IRE-ISA Joint Automatic Control Conference
University of Colorado
Boulder, Colo.
June 28-30, 1961
(Final date for †TP—Mar. 30, ‡CP Syn.—Apr. 14, CPMs—Apr. 24)

Pacific General Meeting
Hotel Utah
Salt Lake City, Utah
August 23-25, 1961
(Final date for †TP—May 25, ‡CP Syn.—June 5, CPMs—June 19)

AIEE-ASME Engineering Management Conference
Hotel Roosevelt
New York, N. Y.
September 14-15, 1961
(Final date for †TP—June 16, ‡CP Syn.—June 30, CPMs—July 11)

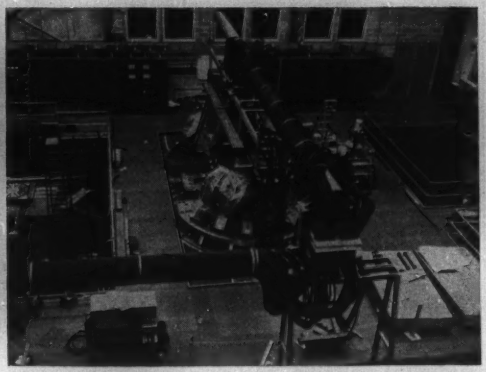
Fall General Meeting
Statler-Hilton Hotel
Detroit, Mich.
October 15-20, 1961
(Final date for †TP—June 14, ‡CP Syn.—July 27, CPMs—Aug. 11)

Winter General Meeting
Hotel Statler
New York, N. Y.
January 28-February 2, 1962
(Final date for †TP—Oct. 30, ‡CP Syn.—Nov. 9, CPMs—Nov. 24)

*Final date for submitting papers—closed
[1]No conflict in subject matter
[2]Planned to coincide

†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Author's Guide*.
For a copy, write to E. C. Day, 33 W. 39th St., New York 18, N. Y.



BELL Telephone Laboratories engineer, H. D. Irvin (*left photo*), appears at the console of "Sibyl," the mechanized oracle which may help predict the future in communication devices and systems. The Laboratories will be visited by AIEE engineers and guests at the Winter General Meeting. The Model "C" stellarator (*right photo*), now nearing completion, will be viewed on an inspection tour to the James Forrestal Research Center on Tuesday, January 31. This stellarator will be America's largest facility for the study of hot ionized gases.

Large Technical Program Scheduled for Winter General Meeting in New York

THE 1961 AIEE Winter General Meeting to be held at the Statler-Hilton Hotel, meeting headquarters, and the Governor Clinton Hotel, New York, N.Y., January 29-February 3, will feature one of the largest technical programs in the history of the Institute. Social activities for which the Winter General Meeting is well known will again be outstanding. A group of varied and interesting inspection trips has been arranged, closely allied with the general session.

General Session

During this session, the Institute's Edison Medal will be awarded to AIEE Past President H. S. Osborne, retired chief engineer, American Telephone and Telegraph Company. A feature of the meeting will be the first presentation of the Mervin J. Kelly Award to Dr. M. J. Kelly, retired chairman of the board, Bell Telephone Laboratories, Inc., for outstanding contributions in the technology of telecommunication, as a distinguished organizer and an eminent leader.

The AIEE Prize Paper Awards will also be presented at this time. AIEE President C. H. Linder will open the session with his report of the members of the Institute. The 1961 Nominating Committee will also report.

The Communications Switching Committee is sponsoring several unusual sessions at the Winter General Meeting. On Friday, the first American disclosures will be made on the British Electronic Switching Development. Representatives of the British Post Office and Automatic Telephone and Electric Company will describe the plans and progress of the Joint Electronic Research Committee for introducing Electronic Telephone Switching in Great Britain.

On Thursday, the Communications Switching Committee is sponsoring a trial of a "reporter" session on the subject of Automatic Toll Ticketing Techniques. Since this is a vital subject in direct distance dialing and since the method of presentation is unusual, this session should be very interesting. Also on Friday, the Automatic Electric Laboratories will present a series of papers on their Electronic Private Automatic Branch Exchange. This is another first in electronic switching.

Registration

The registration fee for members will be $6 and for nonmembers $10. There will be a $2 fee for each lady guest. No fees will be charged for students.

Informal Tea

This social gathering before the formal program begins has been enjoyed by more and more persons each year. This year, the informal tea will be held Sunday afternoon, January 29, from 4 p.m. to 6 p.m. in the Ballroom of the Statler-Hilton. There will be no charge.

From 2 p.m., the registration facilities will be open for those who wish to avoid the Monday morning rush.

Hotel Reservations

Blocks of rooms have been set aside at both convention hotels, the Statler-Hilton and Governor Clinton, for members and guests attending the meeting. Requests for reservations should be sent to the hotel selected specifically referring to the AIEE meeting in the letter. Those who wish to attend should not write to more than one hotel. If the request cannot be filled, the hotel will automatically refer the request to the Hotel Accommodations Committee whose duty it is to obtain a similar reservation at another nearby hotel. The hotel will confirm directly to the member.

Because of the crowded conditions in New York hotels, it is suggested that the reservation be made for arrival on Sunday, January 29, thereby avoiding delays in registration or unavailability of rooms in the early morning of subsequent days.

Rooms have been allotted for use during the meeting by the following hotels at the daily rates indicated below:

Statler-Hilton Hotel (meeting headquarters), 7th Ave., 32nd to 33rd Sts.

Single Room	$ 8 to $15
Double Room	11 to 20
Twin Bedroom	15 to 25

Hotel Governor Clinton (also used for meetings), 7th Ave., 31st St.

Single Room	$ 8 to $14
Double Room	10 to 16
Twin Bedroom	12 to 18

All rooms have private bath and the rates quoted are subject to a 5% New York City hotel room tax.

Smoker

One of the social highlights of the Winter General Meeting will be the Smoker on Tuesday evening, January 31, in the Grand Ballroom of the Hotel Statler-Hilton. Here will be found good food, good fellowship, and top quality entertainment.

It is strongly recommended that requests for tickets be sent in at an early date. The price of the ticket will be $11.50 and requests should be addressed to AIEE Smoker Committee at 33 W. 39th St., New York 18, N.Y., and accompanied by checks made payable to "Special Account, Secretary, AIEE."

Dinner-Dance

The Dinner-Dance will be held Thursday evening, February 2, in the Hotel Statler-Hilton. Dress will be formal. Those interested in attending are urged to write soon for reservations for tables for 10. The price this year is $14 per ticket and requests should be sent to AIEE Dinner-Dance Committee at 33 W. 39th

PREPRINT PRICES

50¢ to Members.
$1.00 to Nonmembers.

ALL MAIL ORDERS must be accompanied by remittance in full or coupons.

COUPON BOOKS in $10 denominations may be purchased.

NUMBERED PAPERS only are available.

SEND ORDER and remittance to:
AIEE Order Department
33 West 39th Street
New York 18, N. Y.

St., New York 18, N.Y., accompanied by checks made payable to "Special Account, Secretary, AIEE."

Inspection Trips

A program of inspection trips of both technical and general interest has been arranged for those attending the Winter General Meeting. Since the number of persons who may be accommodated on each of these trips is limited, members who are interested are urged to make arrangements and obtain full details at the Inspection Trips desk immediately after registering. Tickets are required for all trips.

Inspection trips will be made to the following places:

Thursday, February 2 (afternoon). Anaconda Wire and Cable Company, Hastings on Hudson, N. Y. (See *Electrical Engineering*, June 1959, pp. 624-30.)

Wednesday afternoon and Thursday morning, February 1 and 2. Astoria Generating Station, Consolidated Edison Company of New York, Inc., New York, N. Y. Adults only. No cameras permitted.

Wednesday, February 1 (afternoon). Bell Telephone Laboratories, Murray Hill, N. J. The group will assemble in the Arnold Auditorium at 2 p.m. There will be a talk by K. G. Van Wynen, public relations supervisor, describing the Laboratories, their place in the Bell System, and their operations in research and development. Following this, there will be a lecture on satellite communications. Small groups will visit a cross section of different laboratories to present a broad picture of the scope of science covered by the Laboratories.

Thursday, February 2 (all day). Brookhaven National Laboratory, Upton, N. Y. The bus will leave the Statler-Hilton at 8:00 a.m. and return at 5:30 p.m. Cost of advance reservation is $6.

Wednesday, February 1 (afternoon). Ford Motor Company, Mahwah, N. J. Adults only. No cameras are permitted.

Thursday, February 2 (afternoon). Holophane Light and Vision Institute, New York, N. Y. Refreshments will be served at the conclusion of the visit.

Tuesday, January 31 (afternoon). Indian Point Nuclear Electric Generating Station, Consolidated Edison Company of New York, Inc. This will be a "hard-hat" tour.

Wednesday morning and Thursday afternoon, February 1 and 2. International Business Machines Corporation, New York, N. Y.

Tuesday, January 31 (all day). James Forrestal Research Center, Princeton, N. J. Adults only. No cameras are permitted. The bus leaves the Statler-Hilton at 8:30 a.m and returns at 5:30 p.m. Cost of advance registration is $6.

Wednesday and Thursday, February 1 and 2 (afternoons). New York Times, New York, N. Y.

Tuesday, January 31 (afternoon). New York City Transit Authority, Brooklyn, N. Y.

Thursday, February 2 (afternoon). Queen Mary, Cunard Line, New York, N. Y.

Thursday, February 2 (morning). Rambusch Decorating Company, New York, N. Y.

Tuesday, January 31 (morning). Radio City Music Hall, New York, N. Y. No women or children are permitted.

Wednesday, February 1 (afternoon). Sikorsky Aircraft, Division of United Aircraft Corporation, Stratford, Conn. Located just north of Stratford, northeast of Bridgeport, the plant is adjacent to the Housatonic River crossing of the Merritt Parkway. Citizenship is required for this tour. No cameras will be allowed. Adults only may attend.

Wednesday, February 1 (morning). United Nations General Assembly Building, New York, N.Y. The Present United Nations schedule lists committee sessions only, and admission tickets at no charge will be available for optional group attendance after lunch about 2 p.m. Arrangements may be made for group luncheon, not included in the tickets, in the Delegates Dining Room. The lunch is recommended but optional.

Ladies Entertainment

The Ladies Entertainment Committee has planned an interesting week for ladies attending the 1961 Winter General Meeting.

These plans include a Coffee Hour each morning, Monday through Friday. On Monday afternoon, a tea will be held. For Tuesday, a visit has been scheduled to the Sunnyside home of Washington Irving, followed by luncheon at the Villa Arturo. In the evening, a cocktail hour will be held, followed by dinner and entertainment. A trip will be made on Wednesday to the United Nations Building. On Thursday, the ladies will have breakfast at B. Altman & Company, and at noon, a luncheon and fashion show at the Hotel Sheraton East. The Coffee Hour on Friday will close the activities of the week.

Winter General Meeting Committee

Members of the 1961 Winter General Meeting Committee are: R. W. Gillette, chairman; W. G. Vieth, vice-chairman; J. J. Anderson, secretary; R. T. Weil, Jr., AIEE vice-president for District 3 and budget co-ordinator; D. E. Trucksess, representative, Technical Operations Department; C. F. Savage, public relations; R. M. Franklin, general session; M. Lennig, hotel accommodations; F. P. West, registration; W. McConnachie, inspection trips; T. W. Bartlett, monitors; J. G. Derse, smoker; J. E. Bevan, dinner-dance; and Mrs. H. E. Martin, ladies entertainment.

Technical Program

The tentative technical program for the Winter General Meeting follows:

Monday, January 30

10:00 a.m. Morning Sessions

Modern Circuit Techniques I

CP.* The Dynamic Behavior of Negative Resistance Devices. *C. O. Harbourt*, Syracuse University

CP.* Large-Signal Circuit Theory for Negative-Resistance Diodes, in Particular Tunnel Diodes. *M. Schuller, W. W. Gaertner*, Columbia Broadcasting System Labs.

CP.* Tunnel Diodes with Ultra-Linear Characteristics. *J. J. Tiemann*, General Electric Research Lab.

CP.* Increasing the Q of A Filter Through the Use of Tunnel Diodes. *D. Sabih*, Hughes Aircraft Co.

CP.* Tunnel Diode Modulators. *B. M. Rabinovici, J. Klapper*, Radio Corporation of America

Electric Heating

CP.* Reading Electrical Heating Papers in Russian. *R. O. Buckland*, General Electric Co.

CP.* Leakage Currents in Appliance Heaters. *A. B. Boice*, General Electric Co.

CP.* Application of Variable Impedance Devices to Induction Heating. *E. F. McBrien, J. T. Temin*, Ohio Crankshaft Co.

CP61-30. Heat Transfer Aspects of Electric Heating. *B. Rolsma*, General Electric Co.

CP.* High Temperature Radiant Sources. *J. P. Frier*, General Electric Co.

Industrial Power Rectifiers

CP.* Ignitrons for Large Motor Drives. *C. C. Herskind, R. V. Pohl*, General Electric Co.

CP.* Progress in High Power Rectifier Technology—II. *P. J. Colleran, A. Hansen, Jr., E. C. Rettig*, General Electric Co.

CP61-109. Design of Ignition Firing Circuits Utilizing Controlled Rectifiers. *D. C. Graham*, Westinghouse Electric Corp.

CP.* Semiconductor Rectifiers in Motor Drives. *S. J. Roumanis*, General Electric Co.

Telegraph Systems

CP.* Recent Advances in Printing Telegraph Apparatus. *W. Y. Lang*, Bell Telephone Labs.

61-60. Telegraph Distortion and Distortion Measuring. *H. H. Wusteney*, Siemens & Halske

CP.* Advancements in the Facsimile Art during 1960. *W. H. Bliss*, Radio Corporation of America Labs.

Radio Communication Systems

Generator Excitation Systems

CP.* Static Excitation System for Electric Utility Steam Turbine Generators. *L. M. Domeratzky, A. S. Rubenstein, M. Temoshek*, General Electric Co.

CP.* Design and Test of a Static Excita-

*Conference papers will not be reprinted by the Institute; however, they may be available at the meeting at the discretion of the author.

tion System for Elec. Utility Steam Turbine Generators. *L. J. Lane, D. F. Rodgers, P. A. Vance,* General Electric Co.

61-8. Principles of a Simulator for Studying Synchronous Machine Voltage Regulator Problems. *C. Adamson,* Manchester College of Science and Technology; *M. El-Serafi,* Cairo University

61-9. Amplidyne Main Exciter Excitation System. *L. M. Harvey, A. S. Rubenstein, M. Temoshek,* General Electric Co.

61-137. Proposed Excitation System Definitions for Synchronous Machines. AIEE Excitation Subcommittee of the Power Generation Committee, M. Temoshok, chairman

Protective Devices

61-44. Field Tests of Lightning Arrester Voltage and Current Caused by Switching a 220-Kv Line. *M. C. Galiyano, V. C. Detty,* Pennsylvania Power & Light Co.; *A. R. Hileman, C. L. Wagner,* Westinghouse Electric Corp.

61-46. A Mathematical Study of the Thermal Behavior of Silicon Carbide for Valve Blocks. *N. E. Bolen,* Ohio Brass Co.

CP.* Rigorous Arrester Development Testing. *F. V. Cunningham, A. C. Westrom,* Hubbard-Kearney Electrical Research Lab.

CP.* A Graphical Solution of the Separation Distance Between Arrester and Protection and Protected Equipment. Working Group of the Lightning Protective Devices Sub., A. R. Hileman, chairman

Computing Devices

Electrical Insulation

Applied Automatic Techniques

Management

CP.* The Measurement of Engineering Effort. *F. Ames,* General Electric Co.

CP.* Managing Research and Development. *T. H. Hollomon,* General Electric Co.

CP.* Planning, Scheduling, and Measurement of Engineering Development. *R. H. Buescher,* Litton Industries

CP.* Use of the Business Simulator in Management Training. *R. H. Davis,* Westinghouse Electric Corp.

Cathodic Protection

2:00 p.m. General Session

Address: President C. H. Linder

Report of the Nominating Committee by the Chairman

Presentation of the Institute Prize Paper Awards by the President and L. F. Kennedy, chairman, Prize Awards Committee

Presentation of the First Award of the Mervin J. Kelly Award to Dr. M. J. Kelly, retired chairman of the board, Bell Telephone Laboratories, Inc. by the President and Dr. S. R. Warren, Jr., chairman, Recognition Awards Committee.

Presentation of the Edison Medal to Past President H. S. Osborne, retired chief engineer, American Telephone and Telegraph Co. by the President and C. M. Mapes, chairman of the Edison Medal Committee.

Tuesday, January 31

9:00 a.m. Morning Sessions

Electrostatic Processes I

CP61-90. Movement of Air in the Electric Wind of the Corona Discharge. *M. Robinson,* Research-Cottrell, Inc.

CP.* High-Voltage Generation in Space: The Parametric Electrostatic Machine. *A. S. Denholm,* National Research Council; *J. G. Trump,* Massachusetts Institute of Technology; *A. J. Gale,* High Voltage Engineering Corp.

CP61-91. Pulsed Discharges Preceding Sparkover at Low-Voltage Gradients. *G. W. Penney,* Carnegie Institute of Technology; *S. Craig,* General Electric Co.

60-218. Electrostatic Propulsion Concepts for Space Vehicles. *A. J. Gale,* High Voltage Engineering Corp. (Represented for discussion only)

Section Representatives

Safety

Discrete Data Control Systems

CP.* Theory of Pulse-Data Systems Applied to an Input Self-Adaptive Pulse Data System. *C. K. Taft,* Warner and Swasey Co.

61-76. Optimum Control of Nonlinear Discrete-Data Systems. *J. T. Tou, B. Vadhanaphuti,* Purdue University

60-803. The Use of Z Transforms for a Digital Simulation of a Continuous Transfer Function. *P. A. Stephens, Jr.,* Litton Industries

61-77. Time Domain Design of Sampled-Data Control Systems. *M. P. Pastel, G. J. Thaler,* U. S. Naval Postgraduate School (Re-presented for discussion only)

CP.* Panel Discussion on the Status and Future Direction of Sampled Data Control. *J. R. Ragazzini,* R. E. Kalman, RIAS

High-Speed Telegraphy

CP.* Selective Control for Conventional Teletypewriters and High-Speed Data Systems. *C. J. Colombo,* Canadian Pacific Railway Co.

61-29. A Proposed Electronic Method for High-Speed Teleprinters. *N. N. Biswas,* University of Roorkee

BROOKHAVEN National Laboratory's linear accelerator (linac) tank and auxiliary equipment will be viewed during the Winter General Meeting. This tank is 110 feet long and is composed of 11 10-foot sections coupled together. To the right of the tank and toward the rear, are four "towers," which make up the high-power radio-frequency system. The towers are the FTH triodes and cavities. On the left side, against the wall, are cabinets for two separate systems. The small units are the control centers for the linac high vacuum pumps. The large units house the circuits which pulse the quadrupole magnets, which focus the proton beam in the linac.

CP.* SC *3000* High-Speed Communication Printer. *K. M. Gootgeld,* Stromberg-Carlson

CP61-45. High-Speed Communication of Graphic Intelligence with Hard Copy Readout. *J. R. Shonnard,* Westrex Corp.

Radio Communications

CP.* Standardization of Mobile Telephone Service Signaling. *W. J. Dobias,* General Electric Co.

CP61-122. Selectivity and the Performance of a Mobile Receiver. *R. T. Myers, Jr.,* General Electric Co.

CP61-176. A New Concept in Point-to-Point Radio Systems for Light-Density Multichannel Service. *E. E. Nolan, A. T. Ross, W. C. Fisher, H. B. Sutton,* Farinon Electric Co.

CP61-61. The Theory of Single-Ring Circular Antenna Array. *C. E. Hickman, H. P. Neff, J. D. Tillman,* University of Tennessee

61-47. Antenna Matching Unit for H-F Vehicular Whip. *J. R. Gruber, G. J. Seward,* Avco Corp. (Re-presented for discussion only)

Integrating and Digital Instruments

CP61-62. The Extended Scale Demand Register. *D. M. Ham, F. W. Truesdell,* General Electric Co.

CP.* The Design of a Repulsion Magnetic Bearing for Watt-hour Meters. *D. F. Wright,* Westinghouse Electric Corp.

CP.* A General Description of Digital Voltmeters. *C. Stansbury,* National Bureau of Standards

CP.* Design of Resistive Temperature Compensation by Single and Multiple Thermistor Networks. *S. Farhi,* Harowe Precision, Inc.; *S. Groves,* The Bendix Corp.

Insulated Conductors

Central Control Rooms for Power Station

CP.* A Central Control Room for Dickerson Units 1 and 2. *C. W. Schmitz, Jr., C. S. Bilisoly*

CP.* Present Design Practice of Centralized Control Rooms in Pacific Gas & Electric Company's Power Plant. *E. Nilsson*

CP.* Control Room Features at Saint Clair Power Plant. *R. C. Austin, J. L. Voyles*

Switchgear

CP.* Proposed Standard for Molded Case Air Circuit Breakers. Working Group on Molded Case Air Circuit Breakers of AIEE Switchgear Committee, L. H. Romzick, chairman

CP61-130. Interrupting Ratings for Low-Voltage Circuit Breakers on a Symmetrical Basis. NEMA Joint Sections Committee on Air Circuit Breakers, J. D. Wood, chairman

CP.* 5-Kv Metal-Clad Switchgear—1961. *W. A. Carter, A. Conangla, J. E. Nugent*, I-T-E Circuit Breaker Co.

61-131. A New Current-Limiting Motor-Starter Fuse. *F. L. Cameron*, Westinghouse Electric Corp.

CP61-177. Proposed Revision of American Standard Low-Voltage Air Circuit Breakers C37.15, C37-14. AIEE Working Group on Revision of Present Standards for Low Voltage Air Circuit Breakers of the Switchgear Committee, C. E. Asbury, chairman

Semiconductor & Industrial Power Rectifiers and Chemical Industry

CP61-23. Proposed Method of Loss Measurement for Semiconductor Rectifier Equipments. *I. K. Dortort*, I-T-E Circuit Breaker Co.

CP.* Characteristics of Rectifier Cells. *E. J. Diebold*, International Rectifier Corp.

CP61-24. Fatigue Free Silicon Device Structure. *W. B. Green*, Westinghouse Electric Corp.

CP.* Semiconductor Rectifiers for Electrical Railroads. *E. J. Diebold*, International Rectifier Corp.

61-89. Commutation and Destructive Oscillations in Diode Circuits. *I. Somos*, General Electric Co. (Re-presented for discussion only)

Electrical Insulation

Modern Circuit Techniques II

CP61-96. Transistor Amplifier Stages with Prescribed Gain and Static and Dynamic Sensitivity. *J. H. Mulligan, Jr., S. S. Shamis*, New York University

CP61-97. Amplitude Distortion in Transistor Feedback Amplifiers. *J. H. Mulligan, Jr.*, New York University

CP.* Improved AGC Performance for Transistor I-F Amplifiers Using a Cascode Configuration. *J. F. Perkins, Jr.*

61-25. On the Elimination of Null in Modulating and Demodulating Devices. *S. Jones*, Hughes Aircraft Co.

CP.* Transfluxor Frequency Memory. *A. G. Samusenko*, Radio Corporation of America

61-98. Transistor Morse to Teleprinter Code Converter. *J. F. Cuniff, C. E. Theall, Jr.*, C.G.S. Labs., Inc. (Represented for discussion only)

Symposium on Electrostatography

(Recording of Information by Means of Electric Charge Patterns)

CP.* Signal Recording Techniques in Xerography. *C. R. Mayo*, Haloid Xeroc Inc.

CP.* Technique of Digital Electrostatic Recording. *P. A. Stowell*, Burroughs Corp.

CP.* The Videograph Printing Process. *H. A. Dahl, G. H. Jenkinson*, A. B. Dick Co.

CP.* Thermoplastic Recording. *W. E. Glenn*, General Electric Research Laboratory

2:00 p.m. Sessions

Section Representatives

Land Transportation

CP.* Contact Wire Wear. *K. H. Gordon*, Pennsylvania Railroad Co.

CP.* A Justification of Railway Electrification. *H. C. Cross*, Westinghouse Electric International Co.

CP.* Electrical Control Equipment for Disneyland Monorail Trains. *J. J. Stamm*, Westinghouse Electric Corp.

Control Components and Specifications

CP.* The Chairman's Report of 1960. *D. D. Pidhayny*, Space Technology Labs., Inc.

CP61-78. A Set of Standard Specifications for Linear Automatic Control Systems. *J. E. Gibson, Z. V. Rekasius, E. C. McVey, R. Sridhar, C. D. Leedham*, Purdue University

CP.* Proposed D-C Tachometer Specification by NEMA. *E. Luoma*, Reliance Electric and Manufacturing Co.

CP.* Survey of A-C Control Motors. *J. O'Donohue*, Lockheed Electronics

CP.* A Control Components Application of the Stability Factor Method. *A. G. Fonda*, Bell Aerospace

CP.* Gyro Progress Report by Aerospace Industries Association. *C. Janoff*, Bell Aerospace

CP61-85. Servo Motor Characteristics by Impulse Testing. *H. R. Weed*, Ohio State University

CP.* 1960 Activities of the Performance Measurements Subcommittee. *W. Kline*, AiResearch Manufacturing Company of Arizona

Allied Developments in Broadcasting

CP.* Microwave Radio Relay of High-Definition Video Information. *R. Zamer, V. E. Love*, Raytheon Corp.

CP61-181. Noise and Intermodulation Problems in Multichannel Closed-Circuit Television Systems. *G. A. Collins, A. D. Williams*, Bell Telephone Labs.

CP.* FM Stereo Broadcast Field Tests. *A. P. Walker*, National Association of Broadcasters

CP.* Experience With Two-Way Radio Talk Back for Medical Education. *A. P. Fredette*, Albany Medical College

Indicating Instruments and Calibration

CP61-63. An Analysis of Errors in the Calibration of Electrical Instruments. *F. L. Hermach*, National Bureau of Standards

CP60-64. An A-C Ammeter Calibrator Using Tapped Winding Current Transformers. *R. F. Estoppey*, Daystrom, Inc.

CP61-65. Taut Band Suspension Switchboard Instruments. *J. C. Nycz, V. S. Thomander, R. C. Mac Indoe, D. F. Roerty*, Westinghouse Electric Corp.

CP61-66. A Simplified Design of Long-Scale Ammeters and Voltmeters. *C. F. Van Bennekom, R. M. Rowell*, General Electric Co.

Cross Compound Generator Starting

CP.* Cross-Compound Turbine-Generator Turning Gear Synchronization Study: I—Analytical Analysis Using Automatic Digital Computation. *C. M. Lane, T. H. Kuo*, Westinghouse Electric Corp.

CP.* Cross-Compound Turbine-Generator Turning Gear Synchronization Study: II—Field Test Investigation. *C. M. Lane, P. Barth*, Public Service Electric & Gas Co.

CP.* An Approach to Synchronizing Cross Compound Generators on Turning Gear. *J. D. Davidson*, Westinghouse Electric Corp.

CP.* Cross Compounds—Recent Developments in Starting Cross Compound Units. *P. E. Benner*, General Electric Co.; *L. R. Stuve*

60-852. A New Frequency Converter Excitation (FCE) System for A-C Generators. *K. M. Sparrow*, Lima Electric Motor Co. (Re-presented for discussion only)

60-851. Performance of a New Static-Magnetic Exciter and Voltage Regulator for Round Rotor Marine Steam Turbine Generators. *D. F. Talcott, P. Tabor, C. Concordia*, General Electric Co. (Re-presented for discussion only)

System Controls and Economic Dispatch

60-846. Methods of Controlling Generation on Interconnected Power Systems.

CON EDISON'S Indian Point Nuclear Electric Generating Station will be seen on an inspection tour during the Winter General Meeting. This photo is an artist's conception of the station being constructed by Consolidated Edison at Buchanan, Westchester County, New York, on the east bank of the Hudson River. This station will have an electric generating capacity of 275,000 kw, enough to provide for the residential electric needs of about one million New Yorkers.

N. Cohn, Leeds & Northrup Co. (Re-presented for discussion only)

CP61-48. Load Control Response Tests of Unit R2 at Grand Coulee. *M. D. Liechty*, Leeds & Northrup Co.

CP61-49. Economic Dispatch with Phase Angles as Controlling Variables. *H. G. Hedges*, Michigan State University

CP61-50. A Primer on Spinning Reserve. *C. K. Duff*, The Hydro-Electric Power Commission of Ontario

60-844. Incremental Cost of Water Power. *S. Stage, Y. Larsson*, South Sweden Power Co. (Re-presented for discussion only)

Transformers

61-18. Transformer Invented 75 Years Ago. *A. A. Halascy*, Federal Pacific Electric Co.; *G. H. von Fuchs*, Doble Engineering Co.

CP61-28. A Short History of Development of Power Transformers by One Manufacturer. *R. L. Brown*, Westinghouse Electric Corp.

61-58. The Current Comparator and Its Application to the Absolute Calibration of Current Transformers. *N. L. Kusters, W. J. M. Moore*, National Research Council

61-13. Tertiary Windings in Autotransformers. *O. T. Farry*, Wagner Electric Corp.

61-27. Suggestions for Improving the Accuracy of Transformer Noise Tests in the Field. AIEE Working Group on Technical Investigations of Subcommittee on Audible Sound of Transformers Committee, M. W. Schulz, chairman

Industrial Power Rectifiers & Electrochemical Processes

61-20. An Investigation of the Transient Behavior of an Aluminum Pot-Line Installation. *A. Greenwood, W. C. Kotheimer*, General Electric Co.; *C. A. Langlois*, Reynolds Metals Co.

CP.* Committee Report on Electrical Characteristics of Electrochemical Cell Lines. *C. S. Hague*, Westinghouse Electric Corp.; *A. E. Marshall*, Monsanto Chemical Co.; *R. P. Stratford*, General Electric Co.

61-67. Grounding of D-C Structures and Enclosures. D. C. *Hoffman*, General Electric Co.

CP.* Preliminary Report on Survey of Safety Procedures on the Application and Maintenance of Industrial Power Rectifiers. *P. Gomulkiewicz*, Aluminum Company of America.

Electrical Insulation

Industry & Safety

CP.* Safety Considerations in Designing Data Processing Equipment. *B. L. Stone*, International Business Machines Corp.

CP61-108. Electrical Engineering Standards for Industrial & Commercial Power Systems. *J. W. St. Andre*, Kaiser Aluminum & Chemical Corp.

CP61-123. Guide for the Installation in Buildings of Wiring and Equipment Over 600 Volts. An AIEE Preliminary Report Prepared by the Task Force on Medium Voltage Systems of the Industrial & Commercial Power Systems of the Industrial & Commercial Power Systems Committee, D. T. Michael, chairman

CP.* Electrical Safety at Gary Steel Works. *J. T. Seaman*, U.S. Steel Corp.

Electrostatic Processes II

61-92. The Determination and Simulation of the Equivalent Circuits of Electrostatic Precipitators. *J. B. Thomas*, Princeton University; *J. W. Drenning, H. T. Williams*, Koppers Co.

AN inspection tour to Sikorsky Aircraft, a Division of United Aircraft Corporation, will cover all unrestricted manufacturing facilities, including sub-assembly and main-assembly of the world's largest production helicopter. Completed units will be available for inspection and, weather permitting, actual flight operations will be witnessed.

CP.* Prediction of Fly Ash Precipitator Efficiency. *R. Ramsdell*, Consolidated Edison Company of New York, Inc.

CP.* Contact Potentials and the Adhesion of Dust. *G. W. Penney, E. H. Klingler*, Carnegie Institute of Technology

61-93. The Charging of Nonspherical Particles in a Corona Discharge. *P. L. Smith, G. W. Penney*, Carnegie Institute of Technology

Modern Circuit Techniques III

CP.* Threshold Logic and Tunnel Diode Applications. *T. L. Francis, L. D. Wald*, Texas Instruments

CP.* A Logic Device Utilizing Thin Ferromagnetic Films. *R. E. Morley*, Laboratory for Electronics, Inc.

CP.* Thin Film-Tunnel Diode Logical Devices. *T. A. Smay, A. V. Pohm*, Iowa State University of Science and Technology

CP.* Application of Transformer Logic Circuitry. *D. J. Hinkein*, International Business Machines Corp.

61-1. A Low-Level Linear Rundown Circuit for Pulse Height to Pulse Width Conversion. *D. L. Endsley, W. W. Grannemann, T. Summers*, University of New Mexico.

Data Communications Theory

61-101. The Design of an "Error-Free" Data-Transmission System for Telephone Circuits. *B. Rieffen, W. G. Schmidt, H. L. Yudkin*, Massachusetts Institute of Technology

CP.* An Appraisal of "Error Free" Communication Methods. *K. Morgan, J. Metzner*, New York University

61-102. Minimization of Error in Systems with Random Connections. *J. B. Thomas*, Princeton University; *E. Wong*, International Business Machines Corp.

CP.* Computer Simulation of the Use of Group Codes with Retransmission on a Gilbert Burst Channel. *W. R. Cowell, H. O. Burton*, Bell Telephone Labs.

Wednesday, February 1

9:00 a.m. Morning Sessions

Industrial Control

Land Transportation

CP.* A Fresh Approach to Diesel Electric Locomotive Design. *J. C. Aydelott*, General Electric Co.

CP.* Unique Features of 2,500-hp Diesel-Electric Locomotive. *J. C. Aydelott*, General Electric Co.

CP.* Senate Subway System. *W. L. Rubel*, Architect of the Capital; *W. H. Watson, R. E. Stillwagon*

Industrial & Commercial Power Systems

CP61-41. Safety Aspects of Emergency Power Systems. *C. F. Willett, E. J. Dubois*, Automatic Switch Co.

CP61-156. Recent Progress in Safety and Service Continuity in Molded Case Circuit Breakers and Enclosed Switches. *J. E. Bayles, R. R. McGee*, General Electric Co.

CP.* Designing Maximum Safety into Metal-Clad Switchgear. *W. R. Axon*, Federal Pacific Electric Co.

CP61-42. A Case for Safety Grounding of a 4,800-Volt System. *R. W. Sittner*, General Electric Co.; *H. J. Donnelly*, New York Telephone Co.

Nonlinear Control Systems I

61-114. Determining the Response of Nonlinear Systems to Arbitrary Inputs. *R. McFee*, Syracuse University

61-79. Optimum Nonlinear Bang-Bang Control Systems with Complete Roots Part II: Analytical Studies. *P. Chandaket*, Royal Thai Navy; *E. C. Deland*, Rand Corp.; *C. T. Leondes*, University of California

CP61-80. Analysis of a Certain Class of Higher-Order Nonlinear Control Systems. *Mrs. C. Lakshmi-Rai*, Indian Institute of Science

60-1020. Problems of Asymptotic Behavior and Stability. *L. Cesari*, University of Michigan (Re-presented for discussion only)

CP.* Critique of Papers. *K. Chen*, Westinghouse Electric Corp.; *R. E. Kuba*, Power Equipment Co.

Chemical Processes and Refining

CP.* Direct Burial Cables vs. Conduit Systems in Chemical Plants. *P. T. Carmack*, Union Carbide International Co.

CP61-169. An Interlocked Armored Cable Installation in a Class I, Group D, Division II Area. *W. E. Burpee*, Badger Manufacturing Co.; *S. P. Axé*, Atlantic Refining Co.

CP61-31. Aluminum Conduit Use in the Hydrocarbon & Chemical Process Industries. *H. Esch, R. P. Brown*, Kaiser Aluminum & Chemical Corp.

CP.* The X-Ray Gauge as an Analytical

Sensor in the Chemical Industry. *H. N. Hickok*, General Electric Co.

Communication in Biological Systems

CP.* Echolocation by Bats. *D. R. Griffin*, Harvard University; *J. J. G. McCue*, Massachusetts Institute of Technology

CP.* The Detection and Evasion of Bats by Moths. *K. D. Roeder*, Tufts University

CP.* Event Correlation Analysis—A Method for Improving the Significance of Noisy Multiple-Channel Bioelectric Signals. *B. Saltzberg*, Bisset-Berman Corp.

CP.* Adjustment of Living Systems to Information Input Overload. *J. G. Miller*, University of Michigan

Telemetering

CP.* The Language and Elements of Digital Telemetering. *W. T. Wynne*, Leeds & Northrup Co.

CP61-16. Telemetering in the Crude Oil & Crude Oil Products Pipe Line Industry Past, Present, and Future. *I. B. Cloessner*, Humble Pipe Line Co.

CP61-17. Digital Telemetering Techniques. *A. Brothman, E. H. Brothman, R. D. Reiser*, Industrial Process Engineers, Inc.

CP.* Digital Telemetering Techniques Used in Controlling and Monitoring Offshore Well Platforms. *D. K. Butemeyer*, Texas Instruments, Inc.

Computer Application to Power System Engineering

S109A. Third Report on Survey of Electric Utility Applications of Digital Computers, AIEE Computer Application Subcommittee of the AIEE System Engineering Committee, J. E. VanNess, chairman, and AIEE Computer Systems Subcommittee of the AIEE Computing Devices, Committee, S. Levine, chairman

61-52. A Digital Approach to Power Engineering—III (Digital Computer Program). *M. B. Reed, G. B. Reed*, Michigan State University; *J. L. McKinley, H. K. Polk, R. V. Hugo, W. J. Martin*, Public Service Company of Colorado

61-53. A Digital Approach to Power System Engineering—IV. *M. B. Reed, G. B. Reed*, Michigan State University; *J. L. McKinley, H. K. Polk, W. J. Martin*, Public Service Company of Colorado

CP61-54. A Logic for Identifying the Trees of a Graph. *H. W. Hale*, Iowa State University

Transformers

61-59. Detection of Incipient Faults in Transformers by Gas Analysis. *P. S. Pugh*, American Electric Power Service Corp.; *H. H. Wagner*, Pennsylvania Transformer Division—McGraw Edison Co.

CP61-36. CaF_2 As a Coolant and Dielectric in High-Temperature Sealed Dry Type Transformers. *B. F. Allen, G. F. Simmons*, General Electric Co.

CP61-39. Controlled Temperature and Insulation Protection in the Operation of Power Transformers. *F. B. Grace*, Westinghouse Electric Corp.

CP.* Transformer Loadability and the Loading Guides. *C. W. Hiers, J. H. Carpenter*, General Electric Co.

CP.* Utilization Transformers with 7,620-Volt Secondaries and Services for Underground Residential Distribution. *H. G. Hally*, Iowa Power & Light Co.

Switchgear

CP61-132. Mechanical Effects Produced in Oil Circuit Breakers. *M. G. Mathers, P. Wildi*, Federal Pacific Electric Co.

CP61-133. The Trend to Shingle-Tank Oil Breakers for Subtransmission. *E. B. Rietz*, I-T-E Circuit Breaker Co.

CP.* Lightning Surge Voltages in Substations Caused by Line Flashovers. *C. F. Wagner, A. R. Hileman*, Westinghouse Electric Corp.

CP.* Electronics—A New Concept for Recloser Control. *R. E. Riebs, N. J. Reis*, Line Material Industries

Computing Devices

Electrochemical Processes

Magnetic Amplifiers *

61-128. On the Process of Flux Reversal in Multiaperture Ferrite Cores. *I. H. Rowe*, De Havilland Aircraft of Canada; *G. R. Slemon*, University of Toronto

61-129. Detailed Measurements of Slow Magnetization Processes in Tape-Wound Cores. *R. M. Brownell, R. C. Barker*, Yale University

60-874. Initiation of Flux Reversal in Magnetic Amplifier Cores. *F. J. Friedlaender*, Purdue University; *I. P. Leliakov*, General Electric Co. (Represented for discussion only)

CP61-153. Crossed-Field Magnetic Modulators. *A. J. DeMaria*, United Aircraft Corp.

Research Symposium: New Goals in Plasma Energy and in High-Voltage Insulation

CP.* Plasma Energy. *A. E. Ruark*, Atomic Energy Comm.; *C. W. Little*, "C" Stellarator Associates

CP.* High-Voltage Insulation. *J. J. Grebe, R. Boyer, R. C. Mildner*, Dow Chemical Co.

2:00 p.m. Afternoon Sessions

Industrial Control

Land Transportation

CP.* Electrical and Diesel Power on Russian Railroads. *J. W. Horine*, Pennsylvania Railroad Co.

CP.* Symposium on British Electrification Conference. Panel consists of S. V. Smith, Pennsylvania Railroad; H. H. Duehne, New York Central Railroad; K. A. Browne, Chesapeake & Ohio Railroad; J. Stair, Rosemont, Pa.

Industrial & Commercial Power Systems

CP.* Computers in Industrial Power Systems — Performance Analysis. *R. S. Forbes, Jr.*, E. I. DuPont de Nemours & Co., Inc.

CP.* Basic Considerations in the Proper Application of Low-Voltage Current-Limiting Fuses. *P. J. Reifschneider*, General Electric Co.

CP.* Safety in the Application and Testing of Industrial Distribution Protective Devices. *W. A. Weddendorf*, Mutual Boiler & Machinery Insurance Co.

Nonlinear Control Systems II

CP61-81. Rate Diagram Method of Analysis of an On-Off Control System. *H. Patapoff*, Space Technology Labs., Inc.

CP60-82. Mathematical Models for Time-Domain Design of Electro-Hydraulic Servomechanisms. *P.K.C. Wang*, International Business Machines Corp.

CP61-175. The Design of Time-Optimal Electro Hydraulic Servomechanisms. *P.K.C. Wang*, International Business Machines Corp.

61-83. A Linear Switching Condition for Third-Order Positive-Negative Feedback Control Systems. *S. J. Garrett*, Westinghouse Electric Corp. (Represented for discussion only)

CP.* Critique of Papers. *K. Chen*, Westinghouse Electric Corp.; *R. E. Kuba*, Power Equipment Co.

Data Communication Theory

CP.* Information Rate Analysis and Performance Predication for an Operative Digital Data Link. *R. D. Brandsberg*, Remington Rand Univac

CP.* Reliable Data Transmission through Noisy Media. *C. M. Melas*, International Business Machines Corp.

CP.* Further Studies in Error Detection Systems. *G. J. McAllister*, Bell Telephone Labs.

CP.* Data-Transmission Capacity and Reliability of Future Data Transmission Systems. *R. Filipowsky*, Collins Radio Co.

Batteries

CP.* The Silver Oxide-Cadmium Secondary Battery. *P. L. Howard*, Yardney Electric Corp.

CP.* Sealed Silver-Zinc Cells. *A. M. Chritzberg*, Electric Storage Battery Co.

CP.* Sealed Nickel Cadmium Batteries. *R. C. Shair*, Gulton Industries, Inc.

CP.* Maintenance of Storage Batteries and Chargers. *P. B. Wickersham*, Philadelphia Electric Co.

CP.* Fuel Cells, Pounds, Cubic Feet, and Dollars. *E. Willihnganz*, Elec-Autolite Co.

Aircraft, Missile, Ordnance Telemetry

CP.* A New Signal Conditioning System for Space Telemetry. *D. B. Schneider*, Neff Instruments Inc.

CP.* Telemetering of Strains Imposed on Arresting Cables of Carrier-Based Aircraft. *W. B. Filbert*, Bendix Pacific Division

CP.* The Design & Evaluation of a Magazine-Loaded Transistorized Instrumentation Magnetic Tape Recorder. *K. W. Schoebel, R. L. Peshel*, Precision Instrument Co.

CP.* The EPSCO Data Processing System for Air Traffic Control. *L. A. F. Rivas*, EPSCO Inc.

CP.* A NEW Electronic-Mechanical Multiplexer. *F. H. Gerring*, Instrument Design Lab., Inc.

System Planning and Economics

CP61-51. Elimination Methods for Load Flow Studies. *J. E. Van Ness*, Northwestern University; *J. H. Griffin*, General Motors Corp.

61-57. The Cost of Capital in Economic Studies. *F. M. Heck, Jr.*, Potomac Edison Co.

CP61-165. A Test of Direct Economic Dispatch of Real and Reactive Power A Test Analyzer Studies. *F. W. Smith*, Portland General Electric Co.

Transformers

Switchgear

61-3. The Effect of Contact Synchronization on A-C Interruption. *A. M. Howatson*, University of Sheffield

61-134. 20,000-Ampere Mechanical Switch. *P. M. Newgard*, Stanford Research Institute

CP61-135. Vacuum Power Switches: Five Years of Field Application and Testing. *H. C. Ross*, Jennings Radio Manufacturing Corp.

61-136. An Investigation of the Breakdown Strength of Nitrogen at High Temperatures Using a Shock Tube. *A. H. Sharbaugh, P. K. Watson, D. R. White, T. H. Lee, A. Greenwood*, General Electric Co.

Substations

CP61-22. Dorchester 240,000-Kva Underground Substation in Downtown Montreal. *P. L. Ward, L. D'Auteuil, J. Pauze, A. Gaudette*, Quebec Hydro-Electric Commission

CP61-155. 650-Kv Substations for Project EHV. *P. A. Abetti, A. H. Powell*, General Electric Co.; *R. E. Larson*, Aluminum Company of America; *M. D. Robinson*, Stone & Webster Engineering Corp.

CP60-19. Factors to Consider in the Selection of Substation Sites. *W. A. Conklin*, Consumers Power Co.

Tutorial Session on Computer Application to Design Evaluation & Simulation

CP.* Introduction to Design by Computers. *R. B. Wise, B. Mittman*, Illinois Institute of Technology

CP.* Digital Techniques in Feedback Systems Analysis. *J. W. Ryan*, General Electric Co.

CP.* Simulation for System Evaluation. *J. H. McLeod*, Convair Astronautics

CP.* Analog Simulation of Power Systems with Mathematical Models in Monte Carlo. *C. J. Baldwin*, Westinghouse Electric Corp.

CP.* Simulation of Learning Processes. *G. S. Glinski*, University of Ottawa

Electrical Insulation

Tube Techniques and New Tube Developments

CP.* Operation and Applications of Getter-Ion Pumps. *C. V. Larson*. Varian Associates

CP.* Operating Characteristics of the Triode Ion Pump. *W. M. Brubaker*, Bell and Howell Research Center; *A. R. Hamilton*, Consolidated Vacuum Corp.

CP.* Ni-Ti Technique of Sealing Ceramic Electron Tubes. *G. R. Wisser, M. W. Hagadorn*, Sylvania Electronic Tubes

CP.* Heater Cathode Leakage in Electron Tubes. *R. J. Jaccodine, E. R. King*, Bell Telephone Labs.

CP.* The Influence of the Collector Mesh on the Basic Characteristics of Direct-View Storage Tubes. *V. Le Gendre*, Allen B. DuMont Labs.

CP.* Self-Testing Thyratrons. *W. A. Maijala, A. J. Humphrey*, Reliance Electric and Engineering Co.

CP.* A New Ruggedized "Instant-Heat" 175-Mc Power Amplifier Tube for Mobile Applications. *A. Dzik*, Radio Corporation of America

Solid-State Devices

7:30 p.m. Evening Sessions

Forum of Technical Committee Chairmen

Space Communications

CP61-110. Satellites Go Commercial—For Communications. *H. E. Weppler*, American Telephone & Telegraph Co.

CP.* TIROS II—Television Transmission System. *J. Strother*, Radio Corporation of America

CP.* Active Satellite Equipment for Communication Relays. *L. Pollack, D. R. Campbell*, International Telephone & Telegraph Labs.

CP.* Communications With Lunar Spacecraft. *R. D. Gloor*, Space Technology Labs.

Thursday, February 2

9:00 a.m. Morning Sessions

Graduate Education In Electrical Engineering

Sponsored by ASEE (American Society for Engineering Education) Electrical Engineering Division, IRE (Institute of Radio Engineers) Professional Group on Education, and AIEE Education Committee.

Session I—Planned discussion of the objectives and characteristics of graduate education including appropriate criteria with respect to: Faculty, Admissions, Programs of Study, Residence Requirements, and Theses.

Land Transportation

CP.* Epoxy Resins for Electric Apparatus. *I. H. Elbling*, Westinghouse Research Labs.

CP61-43. Analog Simulation of Train Operation. *R. C. Buck*, General Railway Signal Co.

CP.* Maintenance and Rehabilitation of Traction Electric Equipment. *D. E. Stafford*, National Electric Coil Co.

Domestic & Commercial Applications

CP.* Matching Bimetal Elements to Snap-Action Switches. *C. C. Perry, W. M. Chace* Co. and Wayne State University.

CP.* A New Electric Range Thermostat. *S. C. Jordan*, General Electric Co.

CP.* Advanced Appliance Control Techniques. *J. D. Harnden, Jr.*, General Electric Co.

CP.* AIEE and Appliance Engineering—For What and For Whom. *M. A. Fuller*, Whirlpool Corp.

Computers and Logic Devices

CP.* A Study of a Generalized Model for Digital Computer Control of Blending Processes. *G. E. Adams*, General Electric Corp.

CP.* Accuracy Considerations in Digital Control Computer Systems. *W. M. Gaines, W. N. Patterson*, General Electric Corp.

61-73. Plant Identification in the Presence of Disturbances and Application to Digital Adaptive Systems. *P. Joseph, J. L. Lewis, J. Tou*, Purdue University

61-84. Digital Computer Analysis of Closed-Loop Systems Using the Series Approach. *R. K. Adams*, Oak Ridge National Laboratory

Data Communication

CP61-103. The Design of Data-Transmission Systems. *R. G. Enticknap, R. M. Lerner*, Massachusetts Institute of Technology

CP.* A Buffer Store for Data Transmission. *W. A. Baker, F. E. Froelich*, Bell Telephone Labs.

CP.* Punched Card Transmission on Telegraph Switching Systems. *R. Steeneck*, Western Union Telegraph Co.

CP.* Significance of Different Types of Delay Measurements in Digital Systems. *D. L. Favin*, Bell Telephone Labs.

CP.* The Increasing Need for High-Speed and Reliable Digital Communications. *C. A. Strom, Jr.*, U. S. Air Force

Wire Communications I

CP61-111. A Completely Transistorized 600-Channel Multiplex System. *D. W. Sparks*, General Electric Co.

61-112. Type *T-12S-Tr* Transistorized Short-Haul Carrier System. *O. Ishihara, S. Fujita*, Nippon Telegraph & Telephone Public Corp.; *Y. Yamamoto, R. Murakami*, Nippon Electric Co. Ltd.

CP61-113. Pole-Zero Techniques Applied to Voice-Frequency Telephone Lines. *P. Fleming, Jr.*, Automatic Electric Labs., Inc.

60-1250. A Speakerphone System for Large Conference Rooms. *L. R. Huggler*, Bell Telephone Company of Pennsylvania (Re-presented for discussion only)

61-164. The Subscriber Loop Bridge Lifting Problem and Some Methods of Solution. *L. Hochgraf*, Bell Telephone Labs. (Re-presented for discussion only)

Special Instrumentation

CP61-105. High Resolution Differential Tachometer with Suppresed Lower Speeds. *V. B. Kwast*, Daystrom Inc.

CP61-106. Reliability of Industrial Pilot Lights as Indicating Devices. *D. L. Peitit*, Square D Co.

61-107. A Pulse Position Modulator Type Magnetometer. *S. Stricker*, Israel Institute of Technology; *A. A. Wulkan*

CP61-174. A Solid-State Electronic Control System for Industrial Processes. *H. H. Koppel*, Bailey Meter Co.

Transmission & Distribution

Rotating Machinery

CP61-138. Very-Low Frequency High-Potential Testing. *B. V. Bhimani*, General Electric Co.

CP61-139. Resistance and Capacitance Measurement on High-Voltage Insulation at Very Low Frequencies. *B. V. Bhimani*, General Electric Co.

CP61-141. Investigation of Maintenance Tests for Generator Insulation. *C. A. Duke, L. E. Smith, C. A. Roberts*, Tennessee Valley Authority; *A. W. W. Cameron*, Hydro-Electric Power Commission of Ontario

CP61-163. A Simulated Service Test for Evaluation of High-Voltage Turbine-Generator Insulation Systems. *E. A. Boulter, H. N. Galpern, W. D. Bartlett*, General Electric Co.

Symposium—EHV Substations

Panel Discussion on EHV Substations

Super Power Tubes—I

CP.* A Comparison of Approaches to the Generation of Very High Power at Microwave Frequencies. *W. C. Brown*, Raytheon Co.

CP.* The TPOM As A Very-High-Power Broad-Band Amplifier. *P. Guenard, O. Doehler*, Compagnie Generale de Telegraphie Sans Fil

CP.* On the Heating of Output Windows of High Power Microwave Tubes by Electron Bombardment. *D. Preist, R. Talcott*, Eitel-McCullough, Inc.

CP.* Generation, Application, and Transmission of 20-Kw C-W Power at X-Band. *L. T. Zitelli, I. Maltzer*, Varian Associates

CP.* Super-Power Ultra-High-Frequency Amplifier Tube Developments. *A. C. Tunis, R. E. Reed*, Radio Corporation of America

CP.* An Ultra-High-Frequency Super-Power-Amplifier Cavity. *R. N. Clark, H. W. Duris, L. L. Koros*, Radio Corporation of America

Nucleonics

Magnetic Amplifiers

CP61-149. Tunnel Diode D-C Power Converters. *H. F. Storm, D. P. Shattuck*, General Electric Co.

CP61-150. A Magnetically Regulated D-C to D-C Converter Power Supply. *G. Sager*, Stromberg-Carlson Co.

CP61-151. Achieving Maximum Power Utilization in Variable Output Transistor Oscillators. *S. P. Jackson*, Power Equipment Co.

CP61-152. The Effect of the Series Connected Saturable Reactor with Finite Control Impedance on the Ripple Factor of a Single-Phase Full Wave Bridge Rectifier. *S. P. Jackson*, Power Equipment Co.; *H. R. Weed*, Ohio State University

Basic Sciences

Solid State Devices

CP.* The Epitaxial Transistors—How It Is Made and What It Will Do. *P. D. Lynch, M. J. Bentivegna, L. L. Lehner*, Motorola Inc.

CP.* Transistor Design Considerations for Nuclear Radiation Environments. *J. Sluss, T. Miles, P. Bonk*, Philco Corp.

CP.* Advances in Silicon Power Transistors. *T. New*, Westinghouse Electric Corp.

CP.* The Cadmium Sulphide Analog Transistor and Its Applications. *R. W. Smith*, Radio Corporation of America Labs.

CP.* The Binistor—Its Characteristics and Its Applications. *L. Kauffield, E. Jackson*, Transitron Corp.

2:00 p.m. Afternoon Sessions

Super-Power Tubes—II

CP.* Super-Power Beam Tetrodes. *W. P. Bennett, S. G. McNees, L. G. Sutton*, Radio Corporation of America

CP.* High-Power Modulator Tubes and Circuits. *W. E. Harbaugh, T. E. Yingst*, Radio Corporation of America

CP61-172. Cooling of Anodes Subjected to Long Impulses of High Peak Power. *P. W. Crapuchettes*, Litton Industries

CP.* High-Power Triodes for Communications and Industry. *G. V. Weden*, Machlett Labs.

CP.* A New 250-Kw Short-Wave Broadcast Transmitter. *N. W. Maphan*, General Electric Co.

CP.* The Radio-Frequency Excitation of the Heavy Ion Linear Accelerator. *F. Voelker*, University of California

CP.* The RCA 6949 as a Self-Excited Cyclotron Oscillator. *B. H. Smith*, University of California

Man-Machine Aspects of Automatic Programming for Digital Control Systems

CP.* Automatic Programming for Real Time Systems. *A. Siegel*, Computronics

CP61-162. Man-Machine Aspects of Automatic Programming for Numerically Controlled Machine Tools. *D. T. Ross*, Massachusetts Institute of Technology

CP61-74. Programming Techniques for New Electronic Switching Systems. *S. H. Washburn*, Bell Telephone Labs., Inc.

CP61-185. Near Future Applicability of Problem-Oriented Languages to Programming for Real Time Control Systems. *V. A. Vyssotsky*, Bell Telephone Labs., Inc.

Electric Space Heating & Heat Pumps

CP.* Heat Pump Compressor Performance. *C. A. Duberly*, General Electric Co.

CP.* Analysis of Some Methods of Increasing the Heating-Cooling Ratio of Heat Pumps. *S. F. Gilman*, Carrier Air Conditioning Co.

CP.* Multiple vs. Single Heat Pump Installations. *R. D. Roley*, General Electric Co.

CP.* Developments in Thermoelectric Refrigeration. *R. A. Whisnant*, Westinghouse Electric Corp.

Semiconductor Switching Devices and Applications

60-227. Switching Characteristics of Silicon Power Controlled Rectifiers—I. Turn-On Action. *I. Somos*, General Electric Co. (Re-presented for discussion only)

CP*. Turn-Off Time Characterization and Measurement of Silicon Controlled Rectifiers. *R. F. Dyer, G. K. Houghton*, General Electric Co.

CP.* A Semiconductor Variable Speed A-C Motor Drive. *D. C. Griffith, R. M. Ulmer*, Thompson Ramo Wooldridge

CP61-126. Surge Protection of Low-Voltage D-C Circuits. *P. Chowdhuri, L. J. Goldberg*, General Electric Co.

61-127. Proposed Definitions for Semiconductor Switches. AIEE Rectifier Device Working Group of the Semiconductor Switches. AIEE Rectifier Device Working Group of the Semiconductor Rectifiers Com., J. R. Thurell, chairman

60-70. Problems Encountered in Applying the Silicon Controlled Rectifier to Tungsten Lamp Loads. *C. S. Daugherty*, Vickers Inc. (Re-presented for discussion only)

Wire Communications II

CP61-115. Automatic Dialing and Electronic Selection on Railroad Message and Dispatcher Circuits. *O. A. Jorgensen*, Stromberg-Carlson Co.

CP61-116. Transmission Aspects of an Integrated Private Line Telephone System. *R. A. Schaefer*, Wisconsin Telephone Co.

61-117. Telephone Circuit and Equipment Impedances as They Affect Transmission Performance. *P. F. Radue*, Kellogg Switchboard & Supply Co. (Re-presented for discussion only)

61-118. Effects of Cable Irregularities on the Operation of Telephone Repeaters. *S. I. McCaron*, General Telephone Co. of California (Re-presented for discussion only)

CP.* Administration of Exchange Area Trunks for Good Transmission. *J. D. Howard, Jr.*, Southern Bell Telephone & Telegraph Co.

Special Instruments & Auxiliary Apparatus

Transmission & Distribution

Rotating Machinery

CP61-11. Eddy Current Losses of a Drag Cup Rotor with Circular End Plates. *D. Godovanik*, Israel Institute of Technology

CP61-142. A Basic Analysis of the Commutator-less Primitive Machine of Kron. *H. Majmudar*, Syracuse University

60-225. Thermal Relationships in an Induction Motor Under Normal and Abnormal Operation. *W. J. Martiny, R. M. McCoy*, General Electric Co.; *H. B. Margolis*, American Electric Power Service Co. (Re-presented for discussion only)

CP.* Steady-State Voltages and Torques of an Induction Machine with Simultaneous Rotor and Stator Impedance Unbalance. *D. W. Olive*, University of Nebraska

Electronic Transformers

60-231. Ultra-High-Temperature (500 C) Electronic Transformers Part I—Design Considerations. *J. F. Rippin, Jr.*, U.S. Air Force; *H. B. Harms, G. Walters*, General Electric Co. (Re-presented for discussion only)

60-230. Ultra-High-Temperature (500 C) Electronic Transformers Part II—Design Optimization. *G. Walters*, General Electric Co. (Re-presented for discussion only)

CP.* Tentative Proposed Standard for Computer-Type Pulse Transformers. *J. D. Schwartz*, Bell Telephone Labs., Inc.

CP.* Design of Transmission Transformers on a Digital Computer. *J. K. Borkman, F. J. Kasper*, Bell Telephone Labs., Inc.

CP.* Some Aspects of Broadband Transformers. *E. B. Harrison*, Peerless Electrical Products, Inc.

CP.* Consideration of Insulation Behavior in Wide-Band Transformers. *S. W. Zimmerman*, Cornell University

Modern Circuit Techniques IV

CP.* Properties of the Silicon Controlled Rectifier: A Survey. *J. D. Harnden, Jr.*, General Electric Co.

CP.* D-C to D-C Conversion by Means of Silicon Controlled Rectifiers. *R. E. Morgan*, General Electric Co.

61-99. Design of Diode-Switch High-Sensitivity Trigger Circuits. *M. M. Vojinovic*, Carnegie Institute of Technology

CP61-4. An Electronic Stepping Switch Function Generator. *A. F. Nagy*, University of Michigan

61-100. Linear Analysis of the Electromechanical Pulser. *H. C. Pande*, Polytechnic Institute of Brooklyn

60-143. The Design of the Generator Voltage Regulator. *B. M. Van Emden*, Automation Development Corp. (formerly with Hydro-Aire Co.) (Re-presented for discussion only)

Nucleonics

Magnetic Amplifiers

61-35. An Experimental Study on the Ampere-Turn Gain of Ordinary Saturable Reactors. *W. A. Geyger*, U. S. Naval Ordnance Lab.

CP61-146. The Design of a Transistor Controlled Magnetic Amplifier. *R. G. Schieman, K. A. Benjamin*, Reliance Electric and Engineering Co.

CP61-147. A Discussion of the Transient Behavior of Magnetic Amplifiers with a Nonlinear Steady-State Gain Characteristic. *N. E. Nahi*, University of Southern California

61-148. The Analysis of Conventional Single-Ended Magnetic Amplifiers with Inductive-Resistive Load Including the Derivation of Transfer Functions. *N. E. Nahi*, University of Southern California

Communications Switching I

CP61-68. An Approach to Handling Automated Toll Traffic Requiring Operator Assistance. *H. H. Smith*, Stromberg-Carlson Co.

CP61-69. A Low-Cost Number Identifier for Small Telephone Systems. *T. R. Redington*, Stromberg-Carlson Co.

CP61-70. Economical Usage of Magnetic Tape Recording in Toll Ticketing. *M. A. Clement*, Stromberg-Carlson Co.

CP61-71. Some Traffic Considerations in Toll Ticketing. *R. R. Mina*, Stromberg-Carlson Co.

CP.* A New Service in Automatic Toll Ticketing. *R. B. King*, Automatic Electric Labs.

CP.* Experimental SATT Tabulator Using Ferrite Cores. *H. M. Winters*, Automatic Electric Labs.

Graduate Education in Electrical Engineering

Session II: Continuation of the study and discussion begun in Session I

Note: This series will be continued at the spring meeting of the Institute of Radio Engineers in New York City on March 22, 1961.

Friday, February 3

9:00 a.m. Morning Sessions

Methods for Integration of Machine Aids into Man's Design Effort

CP61-180. The Mechanization of Manufacturing Information for Digital Equipment. *R. T. Herbst, D. Leagus, G. A. Sellers, Jr.*, Bell Telephone Labs.

CP.* Computer Aids to the Design and Machine Wiring of Digital Equipment. *E. O. Codier*, General Electric Co.

CP61-104. Implications of Machine Aids to Design. *O. J. Morzenti*, Bell Telephone Labs., Inc.

CP.* Design Automation—A Look at the Future. *G. L. Baldwin, T. H. Crowley, C. W. Rusenthal*, Bell Telephone Labs.

Metal Rolling Mill Electrical Systems

CP.* Electrical Systems Advancements for Steel Mill Processes. *W. H. Dauberman*, Westinghouse Electric Corp.

CP.* The Application of Digital-Analog Techniques for Metal Rolling. *K. R. Thompson, G. A. Branscom*, General Electric Co.

CP.* Sendzimir Mill Requirements for Motors and Control. *D. E. Rea*, Allis-Chalmers Manufacturing Co.

CP.* Speed Regulators for Hot Strip Mills. *K. G. Black*, General Electric Co.

Linear Control Systems

61-14. On the Design of A-C Servo Lead Networks. *G. Weiss*, Polytechnic Institute of Brooklyn

CP.* Informationally Based, Optimally Controlled Physical Systems. *D. L. Herr*, Santa Barbara, Calif.

CP.* Generalized *704* Program for Linear Systems Analysis. *J. W. Ryan*, General Electric Co.

60-1019. A Digital Time Domain Synthesis Technique for Feedback Control Systems. *L. E. Weaver, A. P. Sage, Jr.*, University of Arizona; *R. L. Miller*, U.S. Army Signal Corps (Re-presented for discussion only)

60-1018. Stochastic Time Optimal Control Systems. *M. Aoki*, University of California (Re-presented for discussion only)

CP.* Critique of Aforementioned Papers. *G. C. Newton, Jr.*, Massachusetts Institute of Technology; *R. J. Kochenberger*, University of Connecticut

Communications Switching II

CP.* Features of a 100-Line Electronic Crosspoint P.A.B.X. *J. DeCicco*, Automatic Electric Labs.

CP.* Transmission in 100-Line Electronic Crosspoint P.A.B.X. *R. F. Kowalik*, Automatic Electric Labs.

CP.* Logical Control in 100-Line Electronic Crosspoint P.A.B.X. *R. P. Sanders*, Automatic Electric Labs.

CP.* Philosophy of Design of Ferrite Core Memory for 100-Line Electronic Crosspoint P.A.B.X. *J. P. Shuba*, Automatic Electric Labs.

Transmission & Distribution

Rotating Machinery

CP61-173. High-Frequency Iron Losses in Fractional Horsepower Induction Motors. *V. C. Shaneman*, Westinghouse Electric Corp.

CP.* Analysis of the Intrinsic Characteristics of the AIEE Round Robin Motorette. *L. M. Johnson*, U.S. Naval Research Lab.

60-1255. Performance Calculations in Phase Converters, Single-Phase A-C Drag Cup Tachometer Generators and Single-Phase Brakes. *P. H. Trickey*, Wright Machinery Co.

CP.* The Surge Comparison Testing of Several Types of D-C Armature Windings. *F. A. Scheda*, Westinghouse Electric Corp.

Relays

CP61-124. Bonneville Power Administration Experience with Transferred Trip Over Microwave Radio. *R. E. Dietrich, H. S. Lorentson, T. W. Stringfield*, Bonneville Power Administration

CP61-183. Protective Relaying for the GPU—Penelec 460-Kv Line. *W. W. Turner, C. H. McCullough, L. E. Goff*

CP61-121. The R-C Circuit with Functionally Variable Time Constant and Its Application to Static Protective Relays. *J. Baude*, Allis-Chalmers Manufacturing Co.

CP.* Bridge Methods for the Measurements of Sequence Quantities on 3-Phase Unbalanced Systems. *S. A. Nasar*, University of California

CP.* Automatic Reclosing Following Bus Relay Operation. Working Group of the Relaying Practices Subcommittee of the AIEE Relays Committee, H. J. Sutton, chairman

Microwave Tubes

CP.* A Light-Weight Ku-Band TWT Amplifying Chain. *W. J. Caton, R. E. Bridge*, Radio Corporation of America

CP.* A Study of Signal Suppression in Broad-Band TWT Amplifiers. *M. Freeling, H. J. Wolkstein*, Radio Corporation of America

CP.* Duplexers and Switching Devices in the 4.3-MM Frequency Range. *I. Reingold*, U.S. Army Signal Research and Development Lab.

CP.* Microwave Devices with Field Emission Cathodes. *J. R. Fontana, H. J. Shaw*, Stanford University

CP.* New Developments in Pencil Tubes. *L. P. A. DeBacker*, Radio Corporation of America

CP.* A Low-Cost L-Band Oscillator Package for Air-Traffic-Control Transponders. *P. W. Gipslis*, Radio Corporation of America

Electronics

Basic Sciences

2:00 p.m. Afternoon Sessions

Methods for the Automatic Design of Electronics

CP61-178. Design Automation Survey—A Report to the AIEE Membership. *R. J. Preiss*, International Business Machines Corp.

CP.* A Quasi-Simplex Method for Designing Sub-Optimum Packages of Electronic Building Blocks, *R. H. Glaser*, International Telephone & Telegraph Communications Systems, Inc.

CP.* The Automation of Computer Backwiring Design and Topological Layout. *R. R. Brown, G. F. Putnam*, Minneapolis Honeywell Regulator Co.

CP.* Computer Simulation as a Machine Aid to Switching System Design. *J. A. Bader, W. S. Hayward*, Bell Telephone Labs., Inc.

CP.* Use of a General Purpose Digital Computer for Design and Manufacture of an Airborne Bombing Systems. *G. G. Evans, D. E. Brotherton*, General Electric Co.

Metal Making and Processing Electrical Drive Systems

CP.* Anticipated Problems and Possible Solutions in Continuous Annealing of Thin Tinplate. *A. L. Mozina*, Allis-Chalmers Manufacturing Co.

CP61-10. A Transistorized Tension and Loop Control. *T. E. DeViney*, Square D Co.

CP.* Approach to the Realization of Automatic Blast Furnace Operation. *J. R. Erbe*, Westinghouse Electric Corp.

CP.* Automatic Wheel Wear Compensation for Roll Grinder. *M. L. Ranallo*, Clark Controller Co.

Linear Control Systems and Applications

61-86. The Synthesis of Optimum Systems from Non-Ideal Components. *J. K. Wolf*, U. S. Air Force; *T. R. Williams, J. B. Thomas*, Princeton University

61-72. Random Linear Systems: A Special Case. *A. R. Bergen*, University of California

60-12. Predictive Control System Application. *H. Chestnut, W. E. Sollecito, P. H. Troutman*, General Electric Co.

CP61-154. Damping the First Stage of a Two-Stage Electro-Hydraulic Servo Valve. *T. W. Thompson, P. F. Hayner*, Sanders Associates, Inc.

Communication Switching Systems III

CP.* Semiconductor Gates for Time Separation Switching. *H. S. Feder*, Bell Telephone Labs., Inc.

CP61-75. The British J.E.R.C. Development of Electronic Switching. *T. H. Flowers*, British Post Office Engineering Dept.; *G. Forshaw*, Automatic Telephone and Electric Co., Ltd.

Transmission & Distribution

Rotating Machinery

CP61-143. The Effect of Temperature, Humidity, and Current on Collector Ring and Brush Wear. *D. J. Herder, W. Kerber, Jr.*, General Electric Co.

61-144. Synchronizing and Damping Torque Coefficients of Synchronous Machines. *R. V. Shepherd*, General Electric Co.

CP61-145. The Explanation of the Torque in a Dynamo. *E. I. Shobert II, R. Holm*, Stackpole Carbon Co.

Subminiature Tubes and Environmental Testing

CP.* New Subminiature Tubes Offer Improved Performance. *J. D. Robbins, B. B. Scott*, Sylvania Electronic Tubes

CP.* Design and Application Considerations for the Use of Nuvistor Tetrodes. *I. E. Locke*, Radio Corporation of America

CP.* A Developmental Nuvistor Triode for Small-Signal Grounded-Grid Amplifiers. *W. A. Harris, R. J. Rundstedt*, Radio Corporation of America

61-34. An X-Ray Tube with Grid for Control of Exposures in Cineradiography. *T. H. Rogers*, Machlett Labs., Inc. (Re-presented for discussion only)

CP.* New Insight into Vibrational Testing of Electron Tubes. *F. W. Willardson*, Sylvania Electronic Tubes

CP.* Equipment Design Problems in Testing for Shorts. *F. W. Mintel*, Sylvania Electronic Tubes

Present and Future Trends in Education in Electronics

Panel Discussion:

CP.* J. B. Russel, General Electric Co.

CP.* T. L. Martin, Jr., University of Arizona

CP.* T. F. Jones, Jr., Purdue University

CP.* R. A. Sharp, Iowa State University

Basic Sciences

Dr. H. S. Osborne Awarded Edison Medal for Contributions to Art of Telecommunication

THE Edison Medal Committee of the AIEE has awarded the Edison Medal for 1960 to Dr. H. S. Osborne (AM '10, M '15, F '21, Member for Life), consulting engineer who retired in 1952 as chief engineer of the American Telephone and Telegraph Company. Dr. Osborne was AIEE president in 1942-43.

The presentation of the medal will take place during the general session of the 1961 Winter General Meeting at the Hotel Statler, New York, N. Y., on Monday, January 30, 1961.

The citation which will accompany the medal reads as follows:

> "For his contributions to the art of telecommunication and his leadership and vision in extending its application; for his achievements in the co-ordination of international communication and in national and international standardization; and for his advancement of the engineering profession."

Born August 1, 1887, in Fayetteville, N. Y., he was educated at the Massachusetts Institute of Technology (MIT) from which he received the degrees of B.S.E.E. in 1908 and doctor of engineering in 1910.

Dr. Osborne was employed by the American Telephone and Telegraph Company in 1910 as engineer in transmission and protection. He was advanced, successively, to the position of assistant to the transmission and protection engineer, transmission engineer, operating results engineer, plant engineer, assistant chief engineer, and chief engineer, until his retirement. Since that time, he has been actively engaged as a consulting engineer. He has been a consulting engineer for the Brazilian Traction Light and Power Company since 1953. In 1958, he became consulting editor on communications for the McGraw-Hill Encyclopedia of Science and Technology. In 1953, he was a visiting lecturer on "Case Studies in Electrical Engineering" at MIT.

Government Service Noted

During World War II, he was a special consultant to the Office of the Secretary of War and a member of the Telegraph Committee of the War Communications Board. He was also a member of the Industry Advisory Council of the Federal Specifications Board, the Industry Advisory Committee for Supply Cataloging of the Munitions Board, and the Domestic Communications Industry Advisory Committee to N.P.A. Since 1955, he has been a member of the Executive Committee, Engineering Division, National Research Council, and in 1956 was named a member of the Committee on Urban Research of the Council.

His outstanding efforts in connection with international telecommunications led to his receiving the award of the "Knight of the Royal Order of Vasa" bestowed by the Government of Sweden in 1955.

Dr. Osborne has served the Engineers Joint Council as chairman of the Committee on Unity of the Engineering Profession and as chairman of the Committee on Constitution and Bylaws. He was vice-president of the American Standards Association (1945-51), a member of its Board of Directors (1935-52), chairman of the association's Standards Council (1942-45), and a member of the Joint Conference Committee on Standards of the Department of Commerce and the American Standards Association. In recognition of his many activities in the association, he was awarded the Howard Coonley Medal in 1955.

He served on the International Electrotechnical Commission as its president (1952-55), as president of the U. S. National Council (1951-52), and as chairman of the Executive Council Subcommittee of the U. S. National Council.

Professional Societies

Dr. Osborne is a Fellow of the Acoustical Society of America, the American Physical Society, the American Association for the Advancement of Science, and the Institute of Radio Engineers. He is chairman of the Committee on Engineering Economy of the American Society for Engineering Education, and a member of Tau Beta Pi.

He was active in civic affairs in his home community and worked tirelessly toward gaining higher regard for engineers in their home communities.

Dr. Osborne served the AIEE as president (1942-43), member of the Board of Directors and Executive Committee (1942-43), and on the following Committees: Chairman, Board of Trustees, AIEE Retirement System (1944-45); chairman, Board of Trustees, Volta Memorial Fund (1949-60); chairman, Executive Committee (1942-43); chairman, Finance Committee (1939-42); chairman, Technical Program Committee (1936-39); chairman, Committee on Communications (1931-34); Standards Committee (1923-26, 1952-54, chairman 1923-26); member, Committee on Planning and Co-ordination (1936-42, 1945-46, 1947-49); member, Publication Committee (1936-39); member, Alfred Nobel Prize Committee (1937-42); member, Edison Medal Committee (1936-43, 1947-52); member, John Fritz Medal Board of Award (1942-46); member, Hoover Medal Board of Award (1945-51); member, Advisory Committee on Honors (1957-58), and member, Professional Development and Recognition Department (1958-60).

H. S. Osborne

"Career Center" Planned To Recruit Engineers, Scientists

Mass recruiting of engineering and scientific personnel efficiently organized is planned for New York during the meetings of AIEE and the American Institute of Physics this Winter, according to Careers Inc., a private enterprise employment agency serving an impressive list of industrial clients. Assembly line techniques reported to have been developed during the IRE (Institute of Radio Engineers) Show last March and perfected at the Wescon Exhibit in Los Angeles, Calif., in August, will be employed.

At a specially partitioned and equipped mid-town location, applicants and prospective employers will be brought together anonymously by matching nameless coded resumes and job orders. These "blind dates" are arranged on a mutual selection basis, without benefit of computers. What happens if an applicant elects to be interviewed for the job he already has is not revealed in the announcement.

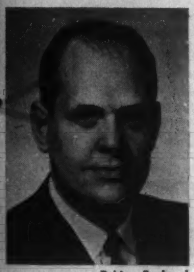
AIEE is in no way involved in or related to this enterprise. For the past 40 years, AIEE has sponsored and supported the Engineering Societies Personnel Service (ESPS), a nonprofit professional employment agency organized to serve the members of the Founder Societies. ESPS has offices in New York, Chicago, and San Francisco, and announces men available and positions monthly in the pages of *Electrical Engineering* and in the journals of the American Society of Civil Engineers; the American Institute of Mining, Metallurgical, and Petroleum Engineers; the American Society of Mechanical Engineers; and the American Institute of Chemical Engineers.

Engineering Societies Building at 39th St. Sold for $1.5 Million

The United Engineering Trustees, Inc., executed a contract of sale for the Engineering Societies Building on 39th Street, New York, on September 30 with the Develop Realty Corporation of New York. The sale price is $1.5 million net to the trustees.

A deposit was made by the purchaser upon signing the contract, and the balance is to be paid upon closing. The required approval of the contract by the New York State Supreme Court has been obtained, and a closing date has been scheduled during January of 1961.

Upon closing the contract and transferring the title, the Trustees will lease back the Engineering Societies Building until the new United Engineering Center is ready for occupancy.



Fabian Bachrach

K. H. Olsen

Dr. W. B. Green

Gene's Studio

Dr. R. R. Johnson

T. H. Thompson

Eta Kappa Nu Association Awards To Be Presented during Winter Meeting

FORMAL presentations of the Eta Kappa Nu Association awards to the Outstanding Young Electrical Engineer of 1960 and honorable mentions will be made at a banquet on January 30, 1961, during the AIEE Winter General Meeting. The banquet will be held in the Governor Room, Hotel Governor Clinton, 7th Ave. at 31st St. Dinner will start at 7 p.m., and the cocktail hour promptly at 6 p.m.

Outstanding Engineer Named

K. H. Olsen of Bedford, Mass., has been named Outstanding Young Electrical Engineer of 1960 by Eta Kappa Nu Association, national electrical engineering honor society. Honorable mentions in this national competition are Dr. W. B. Green of Greensburg, Pa.; Dr. R. R. Johnson of Phoenix, Ariz.; and T. H. Thompson of Basking Ridge, N. J.

All electrical engineers, whether members of Eta Kappa Nu or not, are welcome at the traditional and important event. Ladies are cordially invited.

Reservations for the banquet should be mailed to William Levidow, Room 3B-154, Bell Telephone Laboratories, Inc., Whippany, N. J. Reservations postmarked on or before January 25, 1961, will be honored at $6.50 per person. Later reservations, or those made at AIEE Registration Headquarters during the Winter General Meeting, will cost $7.50 per person. Checks or money orders should be payable to New York Alumni Chapter, Eta Kappa Nu. Attendance at the banquet is limited, and reservations will be honored in the order received up to the limit of space available.

Principal Speaker

A compact, informal yet dignified program has been arranged to honor these truly outstanding young men. The principal address, "Why We Need Engineers as Well as Scientists," will be delivered by Dr. J. R. Pierce, director of research, Bell Telephone Laboratories. Dr. Pierce was an award recipient himself in 1942. This traditional meeting of electrical engineers and their friends has many facets of interest to mature as well as the younger members of the electrical engineering profession.

Eta Kappa Nu, the sponsor of the annual award, is the national electrical engineering honor society founded at the University of Illinois in 1904. The organization has more than 30,000 members, 82 college, and 12 alumni chapters in the principal cities of the United States.

J. N. Landis Elected Head of Engineers Joint Council

J. N. Landis, vice-president of the Bechtel Corporation of San Francisco, Calif., was elected president of Engineers Joint Council (EJC) at a meeting of the Council's Board of Directors on November 18 in New York. EJC is a national federation of 21 engineering societies, which includes the AIEE, organized to advance national and human welfare by promoting co-operation among the various specialties of engineering.

Mr. Landis, who is past president and present Council member of the American Society of Mechanical Engineers, succeeds A. B. Kinzel, vice-president of Union Carbide, who headed EJC for the last year.

The Board re-elected G. E. Holbrook as vice-president. Mr. Holbrook, past president of the American Institute of Chemical Engineers and present vice-president of E. I. du Pont de Nemours & Co., served as EJC vice-president during 1960.

Mr. Landis' engineering career has been mainly in the power field. After a short stint as a mathematics instructor at the University of Michigan, where he received a B.S. degree in mechanical engineering in 1922, he joined the Brooklyn Edison Company in 1923 and remained until 1936. He was with Consolidated Edison during 1936-48, where he served as head of contract control and inspection and assistant mechanical engineer. He joined Bechtel in 1948 as chief power engineer in charge of engineering design and layout of steam-power plants, and became corporation vice-president in 1953.

Mr. Holbrook is also a University of Michigan engineering graduate. He received a B.S. degree there in 1931, an M.S. degree in 1932, and a Ph.D. degree in 1933, all in chemical engineering. He joined the du Pont Company in 1933 and has been with the organization since that time, except for a year's leave in 1952 to serve as deputy director and director, Chemical Division of the Chemical, Rubber, and Forest Products Bureau of the National Production Authority.

At du Pont, Mr. Holbrook was head of new products (1938-43); assistant director of Jackson Laboratory (1943-49); general superintendent of Development of Chambers Works (1949-50); director of the development department (1952); chairman of the Committee on Fellowships and Grants (1953-55); and assistant general manager of the organic chemicals department (1955-57). He has been vice-president, director, and a member of the Executive Committee since 1958.

J. N. Landis

G. E. Holbrook

Louisiana's Carnival City Is Selected

NEW ORLEANS' NEW SKYLINE is dominated here by this $65 million bridge, the longest cantilever span in the United States. New Orleans, La., is the site of the Joint AIEE District Meeting of South East District 4 and South Central District 13, scheduled for April 5-7. This year's meeting, which will be held at the Jung Hotel, will have as its theme: "Progress in the South in the 60's." Chairman J. R. Rombach, Jr., says that the 3-day meeting will cover the field of electricity from its contribution to medicine to its application to missiles. Louisiana's Carnival City is world-famed for its French cuisine and gay entertainment, and attracts thousands of tourists annually.

7th National Symposium Planned To Study Reliability and Quality Control

THE 7th National Symposium on Reliability and Quality Control will be held January 9-11 at the Bellevue-Stratford Hotel, Philadelphia, Pa.

Sponsors of the symposium comprise: AIEE, Subcommittee on Reliability and Quality Control, Committee on Electronics; American Society for Quality Control (ASQC), Electronics Division; Institute of Radio Engineers (IRE), Professional Group on Reliability and Quality Control; and Electronic Industries Association, Engineering Department.

The cost of registration for members of AIEE, IRE, and ASQC will be $20 in advance and $24 at the door. For all others, the registration cost will be $22 in advance and $24 at the door. The price includes payment for the banquet and the *Proceedings*. Extra copies of the *Proceedings* may be obtained at the symposium or from IRE headquarters, 1 E. 79th St., New York 21, N. Y., at a cost of $5. Extra banquet tickets will be obtainable at the Registration Desk for $10.

Registration will begin Sunday, January 8, at 5:00 p.m. in the Burgundy Room on the lobby floor.

The tentative technical program for the conference follows:

Monday, January 9

8:15 a.m. Registration—Burgundy Room

9:00 a.m. Session 1—Keynote Address—Grand Ball Room

Speaker: H. L. Hoffman, president, Hoffman Electronics Corp., will deliver an address on the topic, "Reliability—Whose Responsibility."

10:00 a.m. Session 2A—Statistical Techniques—Clover Room

Moderator: W. R. Pabst, Jr., U. S. Navy, Bureau of Weapons.

Some Discrete Life Testing Distributions. *J. G. Magistad*, Sandia Corp.

Reliability Test Plans. *M. H. Saltz*, Hughes Aircraft Co.

Sampling Plans Based on the Weibull Distribution. *H. P. Goode*, Cornell University.

10:00 a.m. Session 2B—Training Session—Grand Ball Room

Moderator: L. J. Paddison, Sandia Corp.

Basic Statistical Concepts. *F. M. Gryna, Jr.*, Martin Co.

Reliability Prediction. *G. T. Bird*, ARINC Research Corp.

Military Specifications Affecting Reliability. *H. L. Wuerffel*, Radio Corporation of America.

10:00 a.m. Session 2C—Reliability and Quality Control Education—Rose Garden

Moderator: R. T. Weil, Manhattan College.

Reliability Education—Success or Failure. *D. Meister*, Convair.

Training for Reliability and Quality Control. *G. O. Hawley*, Sandia Corp.

Reliability Awareness Campaign. *H. Kimel*, General Electric Co.

1:00 p.m. Registration—1st floor elevator lobby

2:00 p.m. Session 3A—Statistical Techniques—Clover Room

Moderator: G. R. Herd, Booz-Allen Applied Research, Inc.

Statistical Methods Applied to Semiconductors. *W. R. Clemens*, Hughes Aircraft Co.

Sequential Test to Measure and Improve Reliability. *S. A. Bessler*, Sylvania Electric Products, Inc.

System Reliability Confidence Limits. *Miss B. A. Wales*, IBM Corp.

Reliability of Parallel Systems with Repair. *S. G. Kneale*, AVCO Corp.

2:00 p.m. Session 3B—Training Session—Grand Ball Room

Moderator: L. J. Paddison, Sandia Corp.

Reliability Testing of Electronic Equipment. *A. C. Floyd*, Hoffman Electronics Corp.

Manufacturing's Contributions to Reliability. *T. A. Budne*, Statistical Engineering Consultant.

Failure Reporting and Corrective Action Programs. *J. R. Holmes*, IBM Corp.

Field Reliability. *H. Bayer*, Douglas Aircraft Co.

2:00 p.m. Session 3C—Reliability Management—Rose Garden

Moderator: Capt. R. E. Foster, U. S. Navy, Bureau of Ships.

Reliability from the Program Managers Standpoint. *C. M. Ryerson*, Radio Corporation of America.

Intra-Corporation Reliability Co-ordination. *W. J. Picker*, General Precision, Inc.

Reliability Policies in a Multi-Product Company. *J. M. Wuerth*, North American Aviation, Inc.

Case History of a Corporate Reliability Program. *F. McGinnis*, Sperry Gyroscope Co.

7:30 p.m. Session 4—Round Table Discussion—Grand Ball Room

Session Chairman: C. M. Ryerson, Radio Corporation of America.

How Military and Industry can work together toward better reliability training.

How incentives and penalties can be used in contracts to achieve higher equipment reliability.

How "small business" can play a part in helping procure more reliable equipment.

The most important policy matters in reliability that require national attention during 1961.

Tuesday, January 10

8:15 a.m. Registration—1st floor elevator lobby

9:00 a.m. Session 5A—Models and Mathematics

Moderator: Mrs. J. R. Rosenblatt, Bureau of Standards.

A Unique Allocation of Required Part Reliability. *A. M. Breipohl*, Sandia Corp.

Distributions and Their Properties. *A. J. Finocchi*, ITT Corp.

Failure Rate Study for Log-Normal Lifetime Model. *Mrs. L. R. Goldthwaite*, Bell Telephone Labs.

Improving System Reliability. *K. M. Hall*, Sylvania Electric Products, Inc.

9:00 a.m. Session 5B—Accelerated Testing—Grand Ball Room

Moderator: K. W. Davidson, Texas Instruments, Inc.

Accelerated Life Testing of Mica Capacitors. *H. S. Endicott*, General Electric Co.

Accelerated Reliability Testing of Equipment. *A. D. Pettinato*, Rome Air Development Center.

Accelerated Tests and Predicted Capacitor Life. *D. Mannheim*, Sprague Electric Co.

Stress Aging to Failure of Semiconductor Devices. *G. A. Dodson*, Bell Telephone Labs.

2:00 p.m. Session 6A—System Reliability—Clover Room

Moderator: Col. W. Scandrett, Office Chief R&D, U. S. Army

Designing Reliability into the B-58 BNS. *M. D. Katz*, Sperry Rand Corp.

Use and Repair Effects on Availability/Reliability. *P. R. Taylor*, IBM Corp.

Redundancy Considerations in Satellite Systems. *R. H. Myers*, Hughes Aircraft Co.; *L. A. Arolan*, Space Technology Labs.

Effects of On-Off Cycling on Equipment Reliability. *R. J. Boteilho*, ARINC Research Corp.

2:00 p.m. Cost Considerations—Grand Ball Room

Moderator: R. H. DeWitt, Office of Electronics, ODDR&E

Minimizing the Cost of Reliability Testing. *R. T. Maloney*, Sperry Rand Corp.

A. F. Production Experience on AGREE Procedures. *G. W. Lindsay*, Air Material Command.

The Dollar Value of Improved Part Reliability. *E. L. Welker*, ARINC Research Corp.

Design Goal for Reliability. *I. Bosinoff*, Sylvania Electric Products, Inc.

6:00 p.m. Symposium Reception—Clover Room

6:30 p.m. Banquet—Grand Ball Room

Speaker: Maj. Gen. L. I. Davis, USAF Commander, Patrick Air Force Base, Air Force Missile Test Center, will talk on "Reliability for Missiles and Space Operations."

Presentation of Awards:

"1960 National Reliability Award" presented by W. T. Sumerlin, general chairman.

"1960 IRE Professional Group on Reliability and Quality Control Award" presented by P. K. McElroy, Chairman, PGRQC.

"1960-1961 ASQC Electronics Division Award" presented by G. H. Beckhart, Division chairman.

Wednesday, January 11

8:15 a.m. Registration—1st floor elevator lobby

9:00 a.m. Session 8A—Design Techniques—Clover Room

Moderator: Lt. Col. T. T. Brundage, Air Research and Development Command

Design Review—The Why and the How. *R. M. Jacobs*, Sylvania Electric Products, Inc.

Self Checking in Large Scale Digital Computers. *H. S. Rasmussen*, IBM Corp.

Digital Computers for Circuit Analysis. *H. S. Scheffler, Battelle* Memorial Institute.

The Road to Reliable Design. *R. T. Williams*, ARINC Research Corp.

9:00 a.m. Session 8B—Reliability Prediction—Grand Ball Room

Moderator: N. E. Golovin, Rabinow Engineering Company, Inc.

Reliability Growth Prediction During Design. *D. R. Earles*, Martin Co.

Reliability Measureability of a Costly Missile. *E. Pieruschka*, Lockheed Aircraft Corp.

Predicting Failures in a Guidance Set. *W. T. Wells*, Research Triangle Institute.

Transistor Reliability Philosophy Applied to BMEWS. *E. M. Yanis*, Radio Corporation of America.

2:00 p.m. Session 9A—Reliability and Quality Control Programs—Clover Room

Moderator: A. M. Okun, Radio Corporation of America.

Quality Control in Research and Development. *R. G. Fitzgibbons*, Raytheon Co.

Case History of Product Assurance on Polaris. *R. A. Weatherup*, commander, U. S. Navy; *W. Huber*, Sperry Rand Corp.

Results of an Operational Reliability Program. *M. A. Anderson*, Hughes Aircraft Co.

2:00 p.m. Session 9B—Reliability Testing—Grand Ball Room

Moderator: L. J. Jacobson, International Resistance Co.

Methods of Determining Circuit Reliability. *D. M. Larson*, IBM Corp.

The Achievement of Reliability in a Switch Program. *R. D. Murdoch*, Sandia Corp.

Reliability Testing of Aircraft Instruments. *A. C. Evans*, Daystrom, Inc.

Standby papers to be published in the *Proceedings* are, as follows:

Reliability—Taking the Time to Evaluate. *L. G. Rado*, General Precision, Inc.

Reliability Trade-Offs for Repairable Systems. *G. Nagy*, Goodyear Aircraft Corp.

Design Techniques Evaluation for Reliability. *R. E. Warr*, General Electric Co.

An Analog Approach to Reliable Transistor Circuits. *H. T. Gruber*, Battelle Memorial Institute.

Optimal Checking Procedures. *R. E. Barlow*, Sylvania Electric Products, Inc.

A Critical Examination of Reliability Engineering. *E. V. Bersinger*, Radio Corporation of America.

The Use of the Beta Distribution in Reliability. *J. H. Kao*, Cornell University.

The Method of Lagrange Multipliers in Reliability. *K. L. Wong*, Hughes Aircraft Co.

Model Analysis—Non-Linear Estimation Techniques. *N. Rosner*, IBM Corp.

The 1961 National Reliability Award for the best technical paper delivered at this symposium will be presented at the 8th National Symposium on Reliability and Quality Control. The Nominating Ballots Box will be located near the Registration Desk in the first floor elevator lobby.

The Board of Directors in charge of symposium management comprises: Board chairman—C. M. Ryerson, Radio Corporation of America, Camden, N. J.; Representing Electronics Division, ASQC—G. H. Beckhart, Radio Corporation of America, Moorestown, N. J.; Representing AIEE—K. S. Koon, International Business Machines Corporation, Owego, N. Y.; and Representing IRE-PGRQC—P. K. McElroy, General Radio Company, West Concord, Mass.

Atomic Power Plant Dedicated

TAKING part in recent ceremonies dedicating the Dresden Atomic Energy Plant of the Commonwealth Edison Company was C. H. Linder who represented the AIEE in his capacity as president of the Institute. The General Electric Company was the prime contractor in the construction of the $50 million 180-megawatt plant. Located 50 miles southwest of Chicago, Ill., this newest atomic power plant is the nation's first full-scale, privately financed nuclear station. In the background is the shell of the nuclear power plant.

FEATURED speaker at the closing luncheon of the AIEE 2nd Power Industry Computer Application Conference was Prof. M. W. H. Davies, electrical engineering professor of the University of London. Shown (*left photo*) are: (*left to right*) Frank Kovalcik, Midwest editor, *Electrical World*; Dr. E. L. Harder, Westinghouse Electric Corporation, conference program chairman; Prof. Davies; and F. J. Maginniss, General Electric Company, general chairman of the conference. An IBM 1620 computer (*right photo*) was one of the several computer displays at the conference. The 1620 was programmed to work a number of sample problems for demonstration purposes. It was also programmed to play Nim against anyone who wanted to try to beat the machine. Other manufacturers that displayed equipment were General Electric Company and Burroughs. Union Electric Company displayed a model of the Taum Sauk Pumped Storage Hydroelectric Project.

World-Wide Attendance Noted at AIEE Computer Application Conference

MORE than 260 engineers from 37 states, Canada, Great Britain, and West Germany, attended the AIEE 2nd Power Industry Computer Application Conference, held November 9-11, at the Chase-Park Plaza Hotel in St. Louis, Mo.

In addition to 2½ days of technical sessions, the conference featured two luncheons, a cocktail party and banquet, an inspection trip to the McDonnell Automation Center, and a number of informal technical discussion groups on various aspects of the application of computers to the power industry.

The technical sessions were divided into four groups. Two sessions on the first day were devoted to electric power system analysis by the use of computers. The other three sessions were devoted to the application of computers in system operation and optimizing, system planning, and data gathering and automation.

Future Developments Predicted

E. L. Hough, vice-president, Union Electric Company, provided the keynote address when he spoke at the opening luncheon on the subject "Our Wonderful World of the Future." The theme of the 2nd Power Industry Computer Application Conference was "Computers and Power—The Brains and Brawn of Industry." Mr. Hough predicted some exciting developments for use in the home, in the field of transportation, and particularly in the electric power field in connection with new energy sources and the use of computers. Mr. Hough stated that a great many of these developments are possible even today, but their widespread application in many cases depends upon economics, which may place them a good many years into the future. For instance, the widespread application of atomic power will depend upon the availability and cost of conventional fuel sources, and the cost of building and supplying the fuel for nuclear power plants. Mr. Hough said that the new sources of power generation, being talked about recently, thermoelectric, thermionic, magnetohydrodynamics, and fuel cells, will probably find their first application as power supplies on space vehicles. They may next become economical in competition with small internal combustion engines, such as are now used for lawn mowers and even in the automobile. The use of these new power generation methods for generating large quantities of electric power will be even further in the future.

Prof. M. W. H. Davies, professor of electrical engineering, Queen Mary College, University of London, spoke to the final luncheon Friday, November 11, on the subject "Computers, Power Systems, and the Future in Britain." Prof. Davies outlined the differences and similarities between electric power systems in Great Britain and those in the United States, reminding those in attendance that electric power in Great Britain is generated entirely by the government, and includes a considerable amount of hydroelectric power. He said the use of computers in system planning and system analysis in Great Britain is about on a parallel with the progress being made in the United States. In Great Britain, he said, this kind of work is done by committees of engineers. They have done considerable work with computers applied to the application of economic dispatch of hydroelectric generation and the most economical use of the available water supplies.

One of the interesting activities at the conference was a series of informal discussions, held on Thursday afternoon and evening, November 10. At the beginning of the conference, a blackboard was available near the registration desk, and those attending the conference were invited to indicate their preference of subjects for informal discussions. As a result, there were 10 separate informal technical discussion groups on Thursday afternoon and evening, which covered a great many different aspects of the application of computers in the electric power field.

McDonnell Automation Center Visited

More than 100 of those attending the conference took advantage of the opportunity to visit the McDonnell Automation Center on the scheduled inspection tour of this facility. The McDonnell Automation Center is a division of McDonnell Aircraft Corporation. This new center in St. Louis County is the largest commercial electronic data processing operation in the Midwest. More than 250 specialists, using equipment valued at more than $7 million provide business and scientific computer service to Mid-America. The installation includes IBM *7090*, *709*, and *705* computers, a *240* amplifier PACE analog facility, an analog network analyzer, and a Burroughs Datatron *204*.

More than 150 persons attended the cocktail party and banquet on Wednesday evening at the Starlight Roof of the Chase Hotel. They were entertained by Dan Blount, director of sales training, International Shoe Company, who spoke on the subject "Think, Radiate, and Explode." Mr. Blount's talk contained a message about the necessity of selling and promoting ourselves and the work that we do.

General chairman of the 2nd Power Industry Computer Application Conference was F. J. Maginniss, General Electric Company, Schenectady, N. Y. The

program chairman was Dr. E. L. Harder, Westinghouse Electric Corporation, East Pittsburgh, Pa. The conference was co-sponsored by the Power Division and the Computing Devices Committee, AIEE.

Local arrangements for the conference were handled by a committee headed by G. S. Whitlow, Union Electric Company, and Dr. P. M. Honnell, professor of electrical engineering, Washington University. Members of the local conference committee were F. R. Arnoldy, finance; D. P. Ayers, meeting facilities; J. R. Burkhart, registration; J. A. Bussmann, Jr., hospitality; and F. R. Summers, publicity. National publicity chairman was F. J. Kovalcik, Midwest editor, *Electrical World*.

Computer Magnetics Featured at AIEE-IRE Technical Meeting

The 1960 Nonlinear Magnetics and Magnetics Amplifiers Conference, held at the Bellevue-Stratford Hotel in Philadelphia, Pa., on October 26-28, featured an expanded program on computer magnetics as well as sessions on theory and application of magnetic amplifiers and magnetic devices used in conjunction with semiconductors.

This conference, co-sponsored by the AIEE Magnetic Amplifier Committee and the Professional Groups on Industrial Electronics and Electronic Computers of the Institute of Radio Engineers, was attended by 250 engineers and scientists.

The 27 papers presented at the conference are included in the conference *Proceedings*, which may be ordered from AIEE Headquarters, 33 W. 39th St., New York 18, N. Y., at the price of $7.

Medicine-Biology Conference Reveals Space Travel's Influence on Medical Science

SCIENTIFIC experiments to anticipate the physiological effects of space on the nation's astronauts will have far-reaching influence on medical science. This was revealed at the 13th Annual Conference on Electrical Techniques in Medicine and Biology held October 31 in the Sheraton-Park Hotel, Washington, D.C.

The conference, at which 25 instrument companies, institutions, and Government agencies staged exhibits, was sponsored by AIEE, Institute of Radio Engineers, and Instrument Society of America.

One report on a bioastronautical research project disclosed an electronic system that can remotely monitor body temperature at five points, respiration volume and flow rate, electrocardiogram waveform and rate, blood pressure, and skin resistance. The system digitalizes the data in IBM code and format, transmits the information over a telemetry link, provides simultaneous analog and digital display, and records data on magnetic tape for later computer analysis.

Another effort to insure the physical well-being of the first space travelers was described in a paper on a research project concerned with assessing the effectiveness of various kinds of protective clothing which might be worn. It was noted that gas impermeable garments to protect the astronauts against the vacuum of space will require that ventilation air be forced between clothing and skin.

Because storage of body heat is one of the most important criteria dictating suit design, temperature, and flow rate and distribution of air, an elaborate system for measuring body temperatures under simulated space conditions has been devised.

It was not difficult for outside observers at the conference to envision the day when patients admitted to a hospital would not only be put to bed but "plugged in" as well. Sensors would continuously monitor their heart action, respiration, blood pressure, and temperature, and relay the information by telemetry to a central control board.

Particular emphasis was placed on the value of continuous monitoring of patients during critical phases of anesthesia, surgery, and in the post-operative state when sudden changes in temperature, blood pressure, and respiration are often decisive. It was reported that electronic devices would have the capability of detecting such changes in a patient's condition more quickly and precisely than is now possible.

It is apparent from the 51 scientific papers scheduled for presentation at the 2-day conference that a number of electronic devices now in use in laboratories and research centers are destined to become standard hospital and clinic equipment. Many of them were revealed to have great potential as tools for the diagnostician.

Such, for example, is a blood cell counter described in one paper. The instrument can determine the cell concentration in highly diluted blood flowing through a chamber by measuring the average fraction of time that a small photoelectrically observed zone is occupied by cells. A continuous readout of concentration appears on a meter.

Instruments for diagnosis and treatment of cardiac conditions received considerable attention at the gathering of medical and electronic scientists. Among the more dramatic developments disclosed in the scientific papers is a miniaturized, solid-state device, that can be implanted subcutaneously or elsewhere in the body for correction of heart olock. The self-contained device, transistorized throughout, measures only 5 centimeters in diameter and 1.5 centimeters in thickness, including its battery.

It was reported that considerable interest has been exhibited in monitoring the fetal heart rate, particularly during labor. Deviation from the normal rate is one indication of fetal distress.

Indicative of the many ramifications of the growing science of medical electronics is the wide range of specialization represented among the more than 1,000 conference delegates. They include cardiologists, biophysicists, biochemists, radiologists, nuclear scientists, urologists, neurophysiologists, opthalmologists, and aeromedical and biomedical electronic scientists.

Jules Schick

CONDUCTING the 1960 Nonlinear Magnetics and Magnetic Amplifiers Conference was the conference committee: (*Sitting, left to right*) O. T. Carver, Finance; D. Katz, Program Committee chairman; F. G. Timmel, Steering Committee chairman; E. V. Weir, Steering Committee, and C. B. Wakeman, Publications Committee chairman. (*Standing, left to right*) R. L. Miller, registration; H. S. Dordick, Local Arrangements chairman; C. H. Colehower, Local Publicity; E. J. Alexander, Steering Committee, and C. W. Lufcy, Steering Committee. (*Not shown*) C. W. Green, Publicity Committee chairman; C. L. Massey, Hotel Arrangements; and R. R. Booth, R. C. Byloff, R. E. Morgan, G. F. Pittman Jr., and J. J. Suozzi, Technical Program Committee.

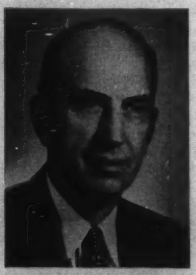
Virginia Section Meeting Held

BLUE RIDGE, Hampton Roads, and Richmond Subsections were represented at an AIEE Virginia Section Meeting held November 10 at the Thomas Jefferson Inn in Charlottesville, Va. Pictured at the banquet are: *(left to right)* D. B. Schneider, secretary-treasurer, Virginia Section; J. W. Davis, vice-president, AIEE District 4; and Dean L. R. Quarles, chairman, Virginia Section. Mr. Davis, the principal speaker, spoke on the subject of "Engineering Responsibilities Outside of Work." Sixty-seven engineers traveled as far as 180 miles to attend. The meeting consisted of three parts: a visit to the operating 1-mw nuclear reactor at the University of Virginia, a social hour, and the banquet.

W. F. Thompson Succeeds Andrew Fletcher as UET President

UNITED Engineering Trustees, Inc. (UET), has announced at its headquarters in New York City, the election of W. F. Thompson, of New Haven, Conn., as president.

Mr. Thompson, who is executive vice-president of Westcott and Mapes, Inc., of New Haven and a former vice-president of the American Society of Mechanical Engineers (ASME), succeeds Andrew Fletcher, of New York, chairman of the Board of Directors of St. Joseph Lead Company, and former president of the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME).



W. F. Thompson

Mr. Thompson, who had been chairman of the UET Real Estate Committee, has relinquished this post to Mr. Fletcher. For the past several years, both have been driving participants in the program resulting in the new United Engineering Center, a $12 million 20-story structure at United Nations Plaza at 47th Street, scheduled to open the latter half of 1961. It will house the world's largest assembly of professional engineering societies.

Other Officers Elected

UET announced also the election of two new vice-presidents and two new members of the Board of Trustees.

The new UET vice-presidents are J. F. Fairman (AM '20, F '35, HM '55, Member for Life), of New York, senior vice-president of Consolidated Edison Company of New York, representing the AIEE, and L. C. Kemp, Jr., of New York, vice-president of Texaco, Inc., representing the American Institute of Chemical Engineers (AIChE).

The new trustees are M. L. Haider, of New York, vice-president and director, Standard Oil Company of New Jersey, representing AIME, and W. H. Wisely of New York, executive secretary of the American Society of Civil Engineers (ASCE).

In his first statement as president, Mr. Thompson spoke of the new United Engineering Center as "a testimonial to the engineering achievements of many thousands of corporations, educational institutions, members of Societies, and others, in the United States and in other countries."

He recognized their generous support as demonstrative of their appreciation of what the many branches of the engineering profession have accomplished in the development of this country and in contributing to the development of other countries.

"We have entered the space age", Mr. Thompson noted. "The new world of engineering achievement is moving forward at a fantastic rate. The impossible is becoming the normal. Much is expected of science and engineering in crossing existing horizons and pushing into the fabulous future. The organizations in the new building, 19 in number, will be the leaders in the conquest of this future."

The newly elected president of UET stated that many hundreds of dedicated members of the engineering professions have given devotedly of their time and abilities in bringing the new United Engineering Center toward realization. "My predecessor, Mr. Fletcher, has been a moving spirit during his two years as president," Mr. Thompson said, "and we are fortunate that his activities will continue at full pace as chairman of the Real Estate Committee."

Known for Outstanding Contributions

Mr. Thompson, who resides in Bethany, Conn., is widely known for his outstanding contributions to the design and construction of steam-electric power plants. At Westcott and Mapes, Inc., he has been in direct charge of design in connection with steam plants for public utilities and industrial plants, as well as the design of office buildings, commercial structures, institutions, schools, oil tank farms, oil blending operations, piers and warehouses, and other major projects.

He became a member of the ASME in 1924, and was elected a Fellow in 1957. In the society, he served as vice-president, as chairman of the New Haven Section, and as a member of the Power Show Advisory, Membership Development, and the Power Test Codes Committees. He has been a director of Engineering Foundation and a member of the Engineers Council for Professional Development. He is a member of the National Society of Professional Engineers.

Mr. Thompson has been chairman of the Industrial and Harbor Development Committee of the Citizens Action Commission, New Haven, and a director of the New Haven Chamber of Commerce.

UET is a nonprofit organization consisting of five Founder Societies: AIEE, ASCE, AIME, ASME, and AIChE.

Nehru Serves Tea to IEC Officers

OFFICERS of the International Electrotechnical Commission (IEC) and heads of delegations were received for tea at the home of Shri Jawaharlal Nehru, Prime Minister of India, during the 1960 meeting of the IEC in New Delhi, India. Shown are: *(left to right)* Hendley Blackmon, president, U. S. National Committee of IEC; Dr. H. S. Osborne, past president of IEC; I. Miletineanu, head of Roumanian delegation; and Prime Minister Nehru.

Punjab Photo Service

United Engineering Trustees, Inc. Annual Report for the Year 1959-60

THE ANNUAL PRESIDENT'S REPORT of the Corporation and its Departments for the fiscal year October 1, 1959, to September 30, 1960, has been issued for the 56th year of the United Engineering Trustees, Inc. (UET) to the Board of Trustees and the Founder Societies.*

General

UET spans five areas of activity: real estate operations (Engineering Societies Building and the United Engineering Center now under construction), Engineering Foundation, as an engineering research operation, Engineering Societies Library, as an educational activity, two medal awards (John Fritz Medal and Daniel Guggenheim Medal), as recognition activities, and custodian activities (Engineers Council for Professional Development, Welding Research Council, Alloys of Iron Research, Corrosion Research Council, Research Council on Riveted and Bolted Structural Joints, etc.). Total assets of the corporation total some $12.7 million market value.

Real Estate—United Engineering Center

The United Engineering Center is considered the most important project the Founder Societies have ever attempted; this building, now in the process of construction, will permit expedient co-ordination of inter-Society activities.

Ground-breaking ceremonies were held on October 1, 1959, and construction started on December 14, 1959. Cornerstone ceremonies were held on June 16, 1960, at which time the Hon. Herbert Hoover and R. F. Wagner, mayor of the City of New York, addressed the presidents of the Societies, other distinguished engineers, and public officials. The United Engineering Center building is proceeding under a schedule which calls for occupancy during the latter half of 1961. Located adjacent to the United Nations on United Nations Plaza at 47th Street, the site is undoubtedly one of the most desirable in New York City.

General Description. The following are important statistics relating to the new building:

Area of plot	37,024.27	square feet
Gross area of building	257,640	square feet
Net Office area	174,000	square feet
Cube of building	3,678,900	cubic feet
Height of building above curb	283	feet
Number of stories (including basement and two mechanical equipment floors at top)	21	
Floor to floor heights		
Basement to 1st	14	feet
1st to 2nd	19	feet 6 inches
3rd to 18th each	12	feet 6 inches
18th to 19th	15	feet 6 inches
19th to 20th	22	feet
20th to roof	18	feet

3 passenger elevators and 1 passenger-freight elevator, each rated for a 3,000-pound load at 700 feet per minute.

1 elevator in Library stack area rated for 1,200-pound load at 75 feet per minute.

Provisions are included for 2 future passenger elevators.

Welded structural steel framing is utilized throughout the building. Exterior walls are predominantly curtain wall construction. Glass and blue-tempered spandrel glass, divided into rectilinear patterns by stainless steel mullions and column sheathing, will enclose most of the tower. Two tower corners and a considerable expanse of base building wall will be faced with limestone.

In addition to executive offices for the Founder and Associate Societies, the new building will include facilities for Engineering Societies Library and Engineering Index. Meeting rooms accommodating approximately 450 people, dining rooms, a cafeteria, and a revolving exhibition of the latest achievements of engineering will contribute towards making this building the center of American engineering activity.

The tower floors will be occupied by the following Founder and Associates Societies:

3rd Floor. United Engineering Trustees, Inc., Engineering Foundation, Engineers Joint Council, Society of Women Engineers, American Institute of Consulting Engineers, Engineers' Council for Professional Development, and Municipal Engineers of the City of New York

4th Floor. American Institute of Industrial Engineers, and American Society of Heating, Refrigerating, and Air-Conditioning Engineers

5th, 6th & 7th Floors. The American Society of Mechanical Engineers

*Those interested in obtaining a copy of the Annual Report including the certificate of audit and balance sheet outlining the financial position of the corporation should write to United Engineering Trustees, Inc., 29 W. 39th St., New York 18, N. Y.

8th Floor. Welding Research Council, and American Welding Society

9th Floor. AIEE, and Illuminating Engineering Society

10th & 11th Floors. AIEE

12th Floor, American Institute of Chemical Engineers

13th & 14th Floors. American Institute of Mining, Metallurgical, and Petroleum Engineers

15th & 16th Floors. Vacant and unfinished—for future expansion

17th & 18th Floors. American Society of Civil Engineers

19th & 20th Floors. Mechanical equipment

The entire building will be air-conditioned with zoned control. Seventy-five foot-candles of illumination will be maintained in offices.

Fund Raising. The general contract with Turner Construction provides for a guaranteed limit of cost of $8,081,216 for the United Engineering Center building. The site cost including demolition and title expenses totals some $2 million. Together with architects' fees, fund raising expense, new building equipment, legal fees, and a building operations fund, the total cost will be about $12.4 million.

The $12.4 million is to be provided by resources as follows:

Depreciation Fund	$ 1,550,000
Sale of 39th Street Property	1,500,000
AIChE Founders Equity	60,000
Industrial Gifts Campaign	5,500,000
Member Gifts Campaign	3,800,000
Total Resources	$12,410,000

Member Gifts Campaign subscriptions as of September 30, 1960 for all the Founder and Associate Societies totaled $3,296,013, and the Industry Campaign pledges totaled $4,954,237.

The Industrial Campaign, under the leadership of its campaign chairman, Dr. M. J. Kelly, is closely nearing its goal.

The Member Gifts Campaign, under the chairmanship of R. E. Dougherty, is vigorously aiming at termination in 1960.

Sale of Engineering Societies Building. Contract of sale for Engineering Societies Building was executed on September 30, 1960, with Develop Realty Corporation, 152 W. 42nd St., New York 36, N.Y. The sale price is $1.5 million net to UET with brokerage commission to be paid by the purchaser. A deposit of $100,000 was made by the purchaser upon signing of contract; the balance of $1.4 million is to be paid in cash upon closing. New York State Supreme Court approval of contract of sale has been obtained and closing date of January 19, 1961, has been scheduled; upon closing, UET will lease back Engineering Societies Building until such time as the United Engineering Center is ready for occupancy.

Engineering Societies Library

Recognizing that the strength of our technology depends to a large extent upon the organization and availability of the world's engineering literature, the Engineering Societies Library, as the educational arm of UET, endeavors to provide engineers with a type of service unmatched elsewhere in the world. Evidence of the usefulness of the Library is demonstrated by a 14% increase in the use of the Library in the last year. The Library translation service covers the various languages of the world.

The Library Board has completed specific planning which will permit the development of an even more useful Library in the proposed new United Engineering Center. With the expansion of facilities, the Library will be able to extend still further the quantity and the quality of its services to all engineers and to industry.

For further details, please refer to the Annual Report of the Director of the Engineering Societies Library which is included herewith.

Engineering Foundation

The Engineering Foundation, as the research arm of UET, endeavors to advance the frontiers of man's engineering knowledge. The Foundation is currently developing a new policy which will tend to utilize more fully the highly skilled talent in our Engineering Societies' membership to define voids in our knowledge and establish needed research in such areas. A new director of the Foundation has been retained on a part-time basis, to pursue development and execution of a new Foundation policy. For further details, please refer to the annual report of the chairman of the Foundation.

Medal Awards

UET is also custodian of two medal awards, the John Fritz Medal Award "for scientific or industrial achievement in any field of pure or applied science," and the Daniel Guggenheim Medal Award for "notable achievements in the advancement of aeronautics."

The 1961 recipient of the John Fritz Medal is S. D. Bechtel as "Engineer, builder, industrialist, and leader of broad vision in large construction undertakings, nationally and internationally . . . a pioneer in the creation and development of the modern construction industry, which is unequalled throughout the world and which has made possible the preeminence of our country in time of war and in time of peace."

The 1960 recipient of the Daniel Guggenheim Medal is Grover Loening as "Pioneer, engineer, public servant, for a lifetime devoted to the advancement of aeronautics in America."

Finances

The certificate of audit and balance sheet for the year ended September 30, 1960, together with supporting statements, outline the financial position of the corporation.

Professional Advisers

Advisers are retained by the Board of Trustees on certain phases of its work in order to obtain the best information available.

Financial Counsel—W. B. Cummings, vice-president, Chemical Bank New York Trust Company

Investment Adviser—Wood, Struthers & Company, M. S. Harrison, partner

Legal Counsel—Simon Presant

Consulting Architects—Shreve, Lamb, & Harmon Associates

Consulting Actuary—G. B. Buck

Insurance Advisers—Frank & DuBois

Auditors—Haskins & Sells, Certified Public Accountants

We are appreciative to them for their wise counsel in the handling of the affairs of the corporation.

Appreciation

We owe a debt of gratitude to G. W. Burpee for financial leadership of the corporation during his 12 years of service as a trustee.

Another trustee who also has earned our sincere appreciation is W. F. Thompson, who, as chairman of the Real Estate Committee for 5 years, has helped initiate and guide our United Engineering Center Project.

I wish to thank all members of the Board of Trustees for their wise counsel during my term as president. On their behalf, sincere thanks are also extended to the entire UET staff including Engineering Societies Library and Engineering Foundation for their outstanding work in the conduct of the affairs of the corporation during the past year.

Respectfully submitted,

ANDREW FLETCHER
President

AIEE-IRE Reciprocal Membership Becomes Effective January 1, 1961

On January 1, 1961, implementation of a reciprocal membership agreement between the AIEE and the Institute of Radio Engineers (IRE) will become effective. By means of this new policy, members of both the AIEE and the IRE may apply for admission to equivalent grade of membership, up to but not including Fellow, in the other society solely on the qualifications submitted to the first society. In accordance with the agreement, the applicant will be granted exemption from payment of the usual entrance fee. This reciprocal membership agreement was approved by the Board of Directors on June 24, 1960.

In applying for admission to AIEE, completion of page 4 (omitting references) of the regular application form no. 400 is all that will be necessary by IRE members. References and a record of professional experience will not be required.

In applying for admission to IRE, similar simple information on IRE membership forms is all that is necessary from AIEE members.

The basis of equivalent grades will be as follows:

AIEE	IRE
Member	Senior Member
Associate Member	Member
Affiliate	Associate

Thermoelectricity Conference Scheduled for January in Dallas

Because of the interdisciplinary nature of technical problems associated with direct energy conversion, there is a need for communication among members of the several technical societies and industrial, university, and military programs. In an effort to provide this communication efficiently, representatives of several societies have suggested joint meetings, the first to be concerned primarily with thermoelectricity. This meeting, entitled the Thermoelectric Energy Conversion Conference, will be held January 8-12 at the Statler-Hilton Hotel in Dallas, Texas.

This is to be an open technical meeting, with the program supplied and conducted by the participating societies. The Department of Defense is acting as cosponsor in order to show its endorsement of the plan. The first meeting, together with subsequent meetings emphasizing other aspects of direct energy conversion, will be supported by an appropriate military service.

Participating societies for the Thermoelectric Energy Conversion Conference are: AIEE, the American Nuclear Society, the American Rocket Society, the American Society of Heating, Refrigerating and Air Conditioning Engineers, the Electrochemical Society, the Institute of Radio Engineers, and the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

The program outline follows:

1. Related Aspects of Direct Conversion
2. Physical Theory
3. Synthesis and Evaluation of Thermoelectric Materials
4. Environmental Effects
5. Materials Fabrication and Assembly
6. Methods of Measurement
7. Design Parameters
8. Device Construction and Performance

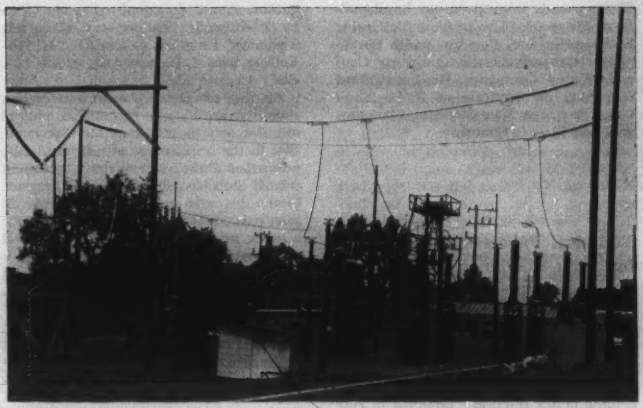
Papers for the first session will be invited. Contributed papers are solicited for the remaining sessions. Papers will be selected for presentation by the Program and Publications Committee on the basis of their technical merit and the extent to which they contribute new scientific information. Both comprehensive developments and brief discussions of specific techniques are welcomed, but not simply descriptions of commercial items.

It is intended that the proceedings of the conference will be published, either as a book or as a supplement to a technical journal. Papers will be included in the published proceedings by agreement of the author and the editors.

EHV Cable Conference Slated April 11-13 at Elmira

The AIEE Extra-High-Voltage (EHV) Cable Conference will be held at Elmira, N. Y., April 11-13 at the Mark Twain Hotel, with an inspection trip to the Cornell Test Site at Ithaca, N. Y.

The proposed schedule of papers to be presented at the conference is as follows:



AN inspection trip to the Cornell Test Site at Ithaca, N. Y., will be made during the AIEE Extra-High-Voltage Cable Conference to be held at Elmira, N. Y., April 11-13, at the Mark Twain Hotel. Shown is the 345-kv Cable Test Installation at Cornell University.

Tuesday, April 11

Morning Session
European Practice of Testing of Cables

Afternoon Session
Cornell Test

Wednesday, April 12

Morning Session
Terminal Installations

Afternoon Session
Cables Installed

Thursday, April 13

Morning Session
Inspection Trip to Cornell EHV Cable Testing Station

Afternoon Session
Discussions at Cornell

Symposium Scheduled on Magnetohydrodynamics

The 2nd Symposium on the Engineering Aspects of Magnetohydrodynamics, sponsored by the AIEE, the Institute of the Aeronautical Sciences, and the Institute of Radio Engineers, will be held March 9-10 at the University of Pennsylvania, Philadelphia, Pa.

A reproducible copy of papers for preprinting is due February 1, 1961. This should be submitted to the chairman of the appropriate session.

If additional information is required concerning the program, the program chairman of each particular session in question should be contacted.

Chairmen of each session are as follows: Communications and Diagnostics Session—C. B. Wharton, Lawrence Radiation Laboratory, Livermore, Calif.; Flight Applications Sessions—Dr. G. S. Janes, Avco Research Laboratories, Everett, Mass.; Fusion Session—Dr. C. W. Little, Atomic Energy Division, Allis Chalmers Manufacturing Company, Milwaukee 1, Wis.; and Power Conversion Session—Dr. G. W. Sutton, General Electric Company, Missile and Space Vehicle Department, Philadelphia 24, Pa.

12,146 Persons Attend 16th Annual NEC in Chicago

Registration of 12,146 persons was recorded for the 16th Annual National Electronics Conference (NEC) held October 10-12 at the Hotel Sherman in Chicago, Ill.

Two outstanding Japanese research scientists presented papers at the conference. Dr. Kazuo Ayaki and Dr. Masanori Kogo of Nippon Electric Company, Ltd., International Telephone and Telegraph affiliate in Tokyo, presented the results of a long development program which has produced a very small channel filter with a high figure of merit.

Dr. D. K. Cheng and M. T. Ma of Syracuse University's electrical engineering department and Dr. Glen Wade of Raytheon Company were named award winners of the NEC. The award was made to Dr. Cheng and Mr. Ma for their paper "A New Mathematical Approach for Linear (Antenna) Array Analysis," in which they demonstrated that analysis of the important properties of the radiation pattern of an array can proceed conveniently from a closed algebraic expression of the array factor, instead of from a polynomial of many terms. The first to be recognized at this conference for a synoptic or tutorial paper, Dr. Wade was named award winner for his tutorial paper, "Parametric Amplification with Solid-State Materials and with Electron Beams." The award-winning papers were originally presented at last year's NEC.

More than 300 exhibitors, occupying a total of 280 exhibit booths, exhibited their products.

Dr. L. W. Von Tersch, NEC president, presented plaques to 15-year exhibitors.

These awards were given to: Amphenol-Borg Electronics Corporation, Ballantine Laboratories, Inc., Boonton Radio Corporation, General Electric Company, General Radio Company, Hewlett-Packard Company, the Institute of Radio Engineers, Raytheon Manufacturing Company, and Sola Electric Company.

Technical Papers Invited for Joint Computer Conference

A call for papers has been issued for presentation at the 1961 Western Joint Computer Conference, to be held May 9-11 at the Ambassador Hotel, Los Angeles, Calif.

The theme of the conference is "Extending Man's Intellect," intended to emphasize the role that computers have played in scientific, technical, and business advances in recent years.

Sponsors of the conference include the AIEE, the Institute of Radio Engineers, and the Association for Computing Machinery.

Technical papers will be presented in the areas of systems, applications, and circuitry for both digital and analog computers. Papers are sought in a wide range of subjects, including large-scale computer systems, thin film memory devices, cryogenic devices, automation theory, pattern recognition, automatic programming, medical uses of computers, language data processing, neural models, and solid state devices and circuits.

Final papers will be due on March 15. The program chairman of the 1961 conference is C. T. Leondes, Department of Engineering, University of California, Los Angeles 24, Calif.

Papers Are Invited on Global Communications

The 5th National Symposium on Global Communications, to be known as GLOBECOM V, will be held May 22-24, 1961, at the Hotel Sherman, Chicago, Ill. The conference will be sponsored by the AIEE and the Professional Group on Communications Systems of the Institute of Radio Engineers.

Technical papers emphasizing the systems aspects of communications technology and related problems are solicited. Some of the areas of interest include:

Transmission Systems—Active and Passive Satellites, Cables, Forward Scatter, Microwave Relay, Long Haul Trunks, and Advanced Communications.

Techniques and Problems—Digital Data Handling, Propagation, Modulation, Multiplexing, Interference, and Voice Compression.

Systems Aspects—Planning, Economics, Switching, Trunking, Frequencies, and Space Communications.

Abstracts of approximately 250 words, with a brief professional record of the author, should be submitted in duplicate by December 31, 1960, to: D. C. Campbell, Technical Program Committee, I.T.T.—Kellogg, 5959 S. Harlem Ave., Chicago 38, Ill.

At the symposium, oral presentation should require about 20 minutes, and 10 minutes will be allocated for discussion. Due to the broad scope of subject matter, groups of authors are invited to submit related abstracts. The Technical Program Committee will endeavor to schedule all such parts, or make special provisions for a single presentation, should the material be of particular merit.

An abbreviated convention record will be prepared for use at the Symposium. Authors are encouraged to submit their full length papers for later publication in the *Transactions* of the Institute of Radio Engineers' Professional Group on Communications Systems, or the AIEE bimonthly *Communications and Electronics*.

Daily, newspaper headlines herald this country's progress in communications technology, especially on the satellite programs. The military and commercial implications of these and other more prosaic developments are being publicized widely. GLOBECOM V will afford an opportunity for giving recognition to the technical side of these advances, with the latest details being provided by the final authorities, the authors.

D. C. Campbell is chairman of the Technical Program Committee.

After-Graduation Panel Highlights Student Meeting

Panel programs provided the backbone for a uniquely successful Student Branch Chairmen and Counselors Conference at Worcester Polytechnic Institute November 18.

The meeting, which was the Fall District 12 Student Activities Committee meeting, was chaired by Prof. F. H. Edwards, counselor at the University of Massachusetts.

The major feature of the conference was a pilot-run for the District 12 student chairmen and counselors of the After-Graduation panel program which is being encouraged by the AIEE this year. This program consists of a panel of practicing electrical engineers who answer questions of students about work in electrical engineering. The questions asked by the student chairmen at Worcester and the straightforward answers given by the panelists made for an unusually informative and stimulating program. Seven of the Branch chairmen announced their intention to arrange for such a meeting for their Branches.

Stephen Noble, Branch secretary at Bradford Durfee College, reported "The After-Graduation panel received great enthusiasm and we immediately planned to have one in our area . . ."

The District 12 Section chairmen were also present for this meeting, and unanimously agreed on the effectiveness of this program in providing a useful service for members of the Branches, and a valuable joint Branch-Section activity.

The panelists were: Dr. M. P. Hnilicka, director of research, National Research Corporation; Dr. W. C. Dunlap, Jr., director of semiconductor research, Raytheon Research Laboratory; J. C. Hitt, electrical engineer, Jackson & Moreland, Inc.; R. G. Porter, television transmission engineer, New England Telephone & Telegraph Company; and H. W. Evirs, Jr., assistant executive engineer, Fitchburg Gas & Electric Light Company.

In charge of arrangements for the panel, and moderator, was F. S. Bacon, Jr., District 12 vice-president.

A second effective feature of the conference was a panel on Branch activities. Each of four student panelists presented a report on his Branch and how he does his job as chairman. The panelists were: Richard de Grasse, University of Massachusetts; Kenneth Nelson, University of Maine; John Bowen, University of New Bedford; and Fred Teillon, Norwich University. Moderator was Prof. David Higginbotham, Tufts University counselor.

The conference delegates were welcomed by Dr. G. A. Richardson, chairman of the electrical engineering department at Worcester Tech. Dr. Richardson said that he considers activity in the Student Branch an important part of the total experience of students in his department.

AIEE PERSONALITIES

J. H. Anderson (AM '36), formerly director of test and inspection, Electro-Motive Division, General Motors, La Grange, Ill., has been named manager of manufacturing facilities.

T. N. Anderson (AM '48), executive vice-president of FXR, Inc., of Woodside, N. Y., has been named president of the firm. Mr. Anderson joined the company less than a year ago as assistant to the founder.

C. A. Ashby, Jr. (M '45) has been elected a vice-president of Stone & Webster Service Corporation, New York, N. Y. Mr. Ashby has been head of the firm's rate department since 1945 and has testified as an expert witness, on behalf of utility clients, before regulatory commissions in several states and Canada and before the Federal Power Commission.

Ralph Berger (AM '56) has been appointed vice-president, engineering, of Rescon Electronics Corporation, Waltham, Mass.

CORRECTION: On p. 1071 of the December 1960 issue of *Electrical Engineering*, the photos of I. M. Ellestad and L. J. Shaffer were interchanged due to a typographical error.

Mr. Berger joined Rescon from Anelex Corporation where he was corporate planner.

A. S. Robinson (M '58) has been appointed director of research of Kollsman Instrument Corporation's Research Division in Elmhurst, N. Y. Prior to joining Kollsman, Dr. Robinson directed the Advanced Electronics Laboratory at the Eclipse-Pioneer Division of Bendix.

H. F. Smiddy (AM '22, M '48, Member for Life), a vice-president of the General Electric Company, received a distinguished service award from the New York Chapter of the New York State Society of Professional Engineers at the society's annual dinner held recently. Mr. Smiddy received the "Award in Industry" in recognition of his distinction and contribution to the industrial engineering profession. He is the founder of the Advanced Management Institute of the General Electric Company.

H. R. Tragesser (AM '42, M '54) has been named distribution manager at Non-Linear Systems, Inc., Del Mar, Calif. Mr. Tragesser came to Non-Linear Systems from the Leland Airborne Division of American Machine and Foundry, Dayton, Ohio, where he was supervisor of design engineering. Mr. Tragesser has served on the AIEE Special Publications Committee (1957-60).

H. A. Wheeler (F '46), a vice-president and a director of Hazeltine Corporation, and founder and president of its subsidiary, Wheeler Laboratories, Inc., has received a Distinguished Achievement Award from seven Long Island colleges—Adelphi College, Polytechnic Institute of Brooklyn, Hofstra College, Molloy Catholic College for Women, St. Johns University, and the U. S. Merchant Marine Academy. The award was presented October 14 at a Joint Academic Convocation at the Long Island Fair.

OBITUARIES

Martin Harvey Clapp (AM '07, Member for Life), retired general contract manager of the Western Union Telegraph Company, died November 6 at the age of 86. Born August 9, 1874, in Montague, Mass., he was educated at the Worcester Polytechnic Institute from which he received the B.S. degree in mechanical and electrical engineering in 1895. For 8 months, he was occupied with the students' course at General Electric Company, Schenectady, N. Y. He was then employed for 8 years at the American Telephone and Telegraph Company, assigned to the installation and maintenance of telephone and telegraph apparatus, the operation of the long-distance lines, and the maintenance of poles and wires. In 1904, he became associated with the Independent Telephone Companies in the Middle West. For a short time, he was chief engineer of the Kinloch Long Distance Company of St. Louis, Mo., and chief engineer of the Rochester Telephone Company at Rochester, N. Y. In 1907, he returned to American Telephone and Telegraph as supervisor of maintenance for the Chicago District. Three years later, he was made division plant superintendent of the Western Union Telegraph Company at Chicago, Ill. In 1911, he became superintendent of telegraph of the Northern Pacific Railway Company at St. Paul, Minn. During World War I, he was manager of the telegraph section of the U. S. Railroad Administration in Washington.

Nikola Y. Fuchs (M '46), special assistant to the general sales manager of Westinghouse Electric International Company, New York, N. Y., died November 9 at the age of 60. A native of Pecuh, Yugoslavia, where he was born on July 15, 1900, Mr. Fuchs was a graduate of the Technical University of Prague in 1924. Mr. Fuchs had been active in the development of power and industrial projects in Europe and the Far East. Early last year, he returned from Djakarta, Indonesia, where he had served for 2 years as a special representative, engaged in negotiations on power developments and in extending the distribution of Westinghouse products. Mr. Fuchs joined Westinghouse in New York in 1950 and served in various sales engineering capacities in the Europe and Africa area sales, project sales, and atomic energy departments. During 1924-30, Mr. Fuchs was an engineer for the Noris K. D. Electrical Company of Zagreb and Belgrade, Yugoslavia. In 1930, he became president, general manager, and owner of the company, at which he supervised the manufacture of cable fittings up to 10,000 volts and outdoor substation fittings and disconnects up to 35,000 volts. In addition, since 1927, this company had been the distributor of heavy equipment for Westinghouse.

Alfred Henry Lovell (AM '12 M '13, F '39, Member for Life), professor emeritus, University of Michigan, Ann Arbor, Mich., died recently at the age of 76. He was born July 13, 1884, in Hamilton, Ont., Canada, and was educated at the University of Michigan from which he received the B.S. degree in electrical engineering in 1909 and the M.S. degree in engineering in 1914. Prof. Lovell was chairman of the university department of electrical engineering during 1945-54 until his retirement. He was assistant dean of the university College of Engineering in 1930-44 and secretary of the college in 1933-44. Before joining the university faculty in 1911 as instructor in electrical engineering, he was employed by the engineering department of the Rochester Railway and Light Company, Rochester, N. Y., in 1909-10, and the engineering department of Muralt and Company, Hamilton, in 1909-11. He rose to assistant professor in 1913, associate professor in 1916, and full professor in 1919. During World War I, he served as an officer in the corps of engineers, stationed in the United States, England, and France. In 1912, he was employed as a designing electrical engineer by the Gladwin Light and Power Company, Gladwin, Mich. The following year, he was associated in the same capacity with the Benzie County Power Company, Beulah, Mich. In 1915, he was employed by the appraisal department of the Detroit Edison Company, Detroit, Mich. He was employed on the appraisal of properties of the Central Texas Ice and Light Company, Mexia, Texas, in 1923. In 1926-27, he worked on the appraisal of the electric power properties of the municipal plant in the City of Hillsdale, Mich. He was the author of the widely used text, "Generating Stations—Economic Elements of Electrical Design." Prof. Lovell served as AIEE District 5 vice-president (1938-40) and director (1932-36). He was a member of the following AIEE Committees: Education (1929-36, 1947-50), Power Generation (1931-36), Economic Status of the Engineer (1936-41, chairman 1938-40), Edison Medal (1938-40), Technical Program (1938-40), and Board of Directors (1932-36, 1938-40).

E. Vernon Potter (AM '51), director, Physics and Electronics Division of the U. S. Naval Civil Engineering Laboratory, Port Hueneme, Calif., died October 6. Born April 29, 1908, in Baltimore, Md., he received his bachelor's degree in 1928 and his doctorate in 1932, both in electrical engineering, from Johns Hopkins University. During 1928-33, he did geophysical research for the U. S. Bureau of Mines, Baltimore, Md. In 1935-39, Dr. Potter was assigned to electrical engineering in the Special Studies Section of the Bureau's Metallurgical Division in College Park, Md. He became chief of the Analytical and Testing Section of the Bureau in Salt Lake City, Utah, during 1939-47. The following year, he headed the Systems Evaluation Section, Sonar Branch, Systems Engineering Department, of Navy Electronics Laboratory, San Diego, Calif. In 1949, Dr. Potter became electronics engineer and head of the Analytic Section, Sonar Design, of the Navy Department's Bureau of Ships, Washington, D. C. He was also employed in the research laboratories of the Bureau of Yards and Docks and was recognized as an authority in the fields of underwater acoustics and electromagnetic radiation. Dr. Potter was a member of Tau Beta Pi, Sigma Xi, the American Geophysical Union, the American Society of Metals, the Research Society of America, the Institute of Radio Engineers, and was a registered professional engineer in the State of Utah.

Thomas George Archibald Sillers (AM '26 M '43), manager of the Allis-Chalmers Manufacturing Company's power systems engineering department, Milwaukee, Wis., died October 26. Born May 24, 1903, in Saskatoon, Sask., Canada, he received the B.S. degree in electrical engineering from the University of Manitoba in 1925. That year, he was employed by Allis-Chalmers as a student apprentice. In 1926, he became associated with the Allis-Chalmers switchgear department which he served successively as engineer in charge of development, assistant chief engineer, and in 1954, chief engineer. He was a registered professional engineer in the State of Wisconsin. Mr. Sillers served on the following AIEE Committees: Transmission and Distribution (1947-48), Switchgear (1953-60), and Research (1957-60).

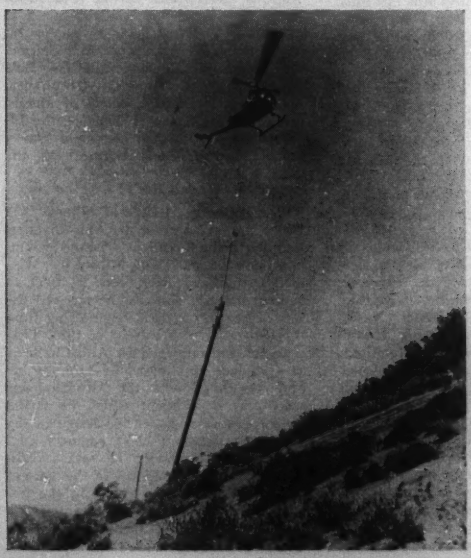
OF CURRENT INTEREST

RUGGED COUNTRY—Pacific Gas and Electric Co. groundsmen feed out line as veteran mountain flier Harry Rogers, chief pilot for the Fresno, Calif., helicopter charter operator, starts another wire-laying run. Operation was carried out on two successive mornings to minimize effect of prevailing winds on both the aircraft and the polemen.

Helicopter Erects Power Line, Saves Month of Road Building

A 2.7-mile-long power line to serve a microwave transmission station high in California's rugged coastal mountains was erected this Fall in only 10 hours by a 305-hp Hiller 12E utility helicopter.

Pacific Gas & Electric Company (PG&E) construction officials estimated that it would have taken a 10-man crew more than a month just to cut a road along the right of way. The project was the final step toward activating a Pacific Telephone & Telegraph Company microwave system between San Jose and San Bernardino, Calif.



AIR/GROUND co-operation positions a 35-foot pole. Pilot could talk to the ground crew by means of a lightweight transistorized loudspeaker, called a Penetrator, mounted on his Hiller 12E's skid gear. Note steeply pitched hillside. Members of the ground crew aid in exact positioning and signal to the pilot when to release the cargo hook holding the pole.

No power source was available on the side of Tassajara Peak up which the building contractors had cut an access road, according to power company officials, who called on the services of Whirl-Wide Helicopters, Inc., of Fresno, operators of 305-hp Hiller 12E's.

Working together from the planning stages, Ron Smith, Whirl-Wide's general manager, and PG&E construction superintendents developed the following work schedule for the air operation.

Several days before the helicopter air lift, a 2-man PG&E crew hiked the proposed right of way with hand digging tools and dynamite. Clambering along steeply pitched slopes covered with Manzanita brush reaching up 5 to 20 feet, the advance team dug and blasted 30 holes, 6 feet deep and 18 inches across, in a beeline up the mountain.

At 6:00 a.m., the actual powerline construction began. The staging area was set at the top of Tassajara Peak where the 35-foot poles had been trucked up the construction access road.

Taking advantage of the windless morning hours, Chief Pilot Harry Rogers, a veteran of mountain helicopter flying, planted 25 fully rigged poles in 4 hours flying time. PG&E groundsmen were on hand for exact positioning and to signal to the pilot to release the cargo hook holding the pole. The pilot could converse with ground crews by means of a ½-mile-range transistorized loudspeaker mounted to the ship's skid gear.

On the second morning, the remaining five poles were placed and wire stringing commenced. Pilot Rogers reeled out 9,000 feet of heavy no. 5 copper well. This consisted of three 3,000-foot lines, each made up of five strands of copper-coated steel, adding up to 1 pound every 4 feet. Since this section of the California Coastal Range between Morro Bay on the

Coast and Paso Robles inland is torn by 100-mph winds in the winter, this heavy-gauge line was necessary.

As each spool was played out, the helicopter merely hovered in the thin mountain air, while the ground crew spliced onto the next reel. Since this same helicopter had carried almost ½-ton loads above 10,000 feet in the Sierra Nevada, hovering out of ground effect with the weight of the wire was routine, although such performance is a stern criterion for most light helicopters.

On the third and final morning, three remaining lines of 7-foot-per-pound aluminum wire were placed on the cross bars in 3 hours rotor time, during which 28,500 feet of wire was laid. This is at the rate of almost 10,000 feet per hour.

The density altitude during the entire operation exceeded 4,000 feet. The 10-hour breakdown for the airlift is as follows: 4½ hours to place 31 poles; 4½ hours wire laying along the nearly 3-mile route; and 1 hour flying involved in transportation to and from staging area, preliminary reconnaissance, and personnel transportation.

Whirl-Wide also supplied a mechanic who, in addition to fueling and greasing the Lycoming-powered copter, attached the power poles to the 1,700-pound helicopter's cargo hook.

This operation, while notable from the ready comparison of time and money saved, represents only one of a number of heavy industrial uses for the new generation of light helicopters in the more-than-300-hp class. Since the Hiller 12E introduction less than 2 years ago, it has successfully introduced transport of heavy material and cargo on several hundred projects throughout the Western Hemisphere. **EE**

Weather Maps Drawn Electronically By New U.S. Weather Bureau Plotter

THE U. S. Weather Bureau put into operational use recently an electronic computer-plotter that mechanically draws a complete weather map of the Northern Hemisphere in less than 3 minutes.

Known as the "Weather Plotter," the electronic unit reads weather information supplied in numerical form on magnetic tape and presents the information to a digital-to-analog converter. The converter instructs the "mechanical hand" of the plotter to draw automatically contours or isobars, which represent lines of barometric pressure, on a 30- by 30-inch map of the Northern Hemisphere.

The Weather Plotter, developed and produced by Electronic Associates, Inc. (EAI), of Long Branch, N.J., was demonstrated at the Bureau's National Meteorological Center, Suitland, Md. The Center has two such units, one of which will be used on a stand-by basis.

Greater Accuracy

According to Dr. G. P. Cressman, director of the Center, the EAI plotter produces a complete weather map in less than 3 minutes, compared with approximately 20 minutes required by the former hand-drawn method. He also noted that this automatic, electronically controlled method produces maps that are far more accurate than those hand-drawn.

Information fed into the Weather Plotter is gathered from more than 500 weather observation stations throughout the Northern Hemisphere. Observations are taken twice daily, at noon and midnight London time, and fed into the Center by teletypewriter.

Forecasts, ranging from 12, 24, 48, and 72 hours ahead, are programmed on a computer and recorded on magnetic tape. The tape is then put on the Weather Plotter for reading, conversion, and map plotting.

During the course of a 24-hour day, 64 weather maps are produced for various altitudes from sea level to 40,000 feet. Each map forecasts air flow patterns for a particular forecast period. Maps of these air flow patterns at 40,000 feet and higher are prepared for use by the military and airlines in determining the best flying routes and altitudes for jet aircraft.

Immediately after each map is produced, it is distributed by facsimile to 26 U. S. Weather Bureau stations throughout the United States for use in local and regional weather forecasting. Maps also are distributed by the same method to more than 600 military airfields and stations, airlines, universities, and commercial weather forecasting operations.

L. F. Christianson, president of Electronic Associates, Inc., noted that units similar to the Bureau's Weather Plotter will soon be installed at Point Mugu and Monterey, Calif., to assist in forecasting weather conditions in planning missile firings from the Pacific Missile Range, and at Strategic Air Command Headquarters at Offutt Air Force Base, Omaha, Neb.

Technical Description

EIA's Magnetic Tape Dataplotter, model *3410*, including a modified EAI *X-Y* Plotting Board, model *205*, (Variplotter) is used to convert digital data recorded on magnetic tape in IBM *704*, *709*, or *7090* format into inked or symbol plots on 30- by 30-inch or smaller graph sheets. Unlike previous models, data may be read directly from magnetic tape, eliminating preparation of punched cards or paper tape. The high tape reading and plotting speeds produce a system considerably faster than any previously available.

Application. In addition to weather chart construction, applications exist within many areas such as automatic drafting, highway planning, map construction, and data reduction. Engineering graphs of frequency response, stress characteristics, and fluid flow are also easily produced. With the model *3410*, large permanent plots are quickly available for

THIS electronic plotter, which automatically draws complete weather maps of the Northern Hemisphere in less than 3 minutes, was put into operational use recently by the U. S. Weather Bureau. The Electronic Associates, Inc., "Weather Plotter" accepts weather forecast information presented on magnetic tape, reads and interprets it and instructs the plotter's "mechanical hand" (at rest in upper right-hand corner of plotting board) to draw contours or isobars that represent lines of barometric pressure.

analysis, reproduction, or inclusion in reports. Line, curve, or symbol plots may be made with equal facility.

High Accuracy and Reliability. The accuracy of the digital and analog circuits is approximately 0.08% of full-scale data, depending on point density and the amount of data smoothing used. High stability wire-wound resistors and silicon diodes are located in a thermostatically controlled oven to give extra protection against changes in environmental temperature. Analog operational amplifiers are chopper stabilized and, except for the tape transport unit, all circuitry is transistorized for greater reliability.

Input Data Range. The Dataplotter plots up to 12-bit binary numbers of positive sign, making its range effectively 4095 counts from 0000 to 4095. Scale factor and parallax controls on the front panel may be used to expand the plot up to 10 times larger and to move the origin (0,0) to any point on the plotting surface depending on the scale used.

Plotting Modes. Two types of plots may be made: (a) line plots in which successive *x-y* points are connected by straight lines; (b) symbol plots (using the Symbol Printer model *17-25D* supplied as standard equipment) in which one of 12 symbols can be selected manually or automatically and printed. The plotting speed in the line plot mode may be as high as 80 points per second.

Independent (Off-Line) Operation. The Dataplotter includes its own tape reader so that an extra IBM *727* or *729* tape unit need not be provided by the user. In addition, this feature permits locating the Dataplotter remotely from the computer. Thus, one Dataplotter may be used to plot runs from several widely separated computers or several Dataplotters may be used simultaneously with the same computer. For further flexibility, the system comprises three physically independent assemblies: the tape transport rack, the console containing all data circuitry and controls, and the horizontally mounted *x-y* plotter. The plotter is also capable of independent operation directly from analog voltages.

Ease of Maintenance. Trouble shooting and maintenance are easily accomplished on the Magnetic Tape Dataplotter. The state of all flip-flops is indicated by neon lamps. All printed circuit cards are mounted on easily accessible rolling drawers, and each card includes a number of color-coded phone-jack receptacles on its edge which allow the outputs of all active elements on the card to be monitored easily. EE

Discovery May Make Possible New Family of Electronic Devices

A DISCOVERY that yields new scientific concepts and may make possible a new family of electronic devices was announced recently by the General Electric Company (GE). An electronic process known as "tunneling," which has previously proved useful in carefully prepared semiconductor materials, has been observed for the first time in devices of simpler configuration. These devices consist of two metal films separated by a thin insulating layer, with one or both of the metal films in the superconducting state, that is, offering no resistance to passage of an electric current.

"This discovery, made by Ivar Giaever of the GE Research Laboratory, is so recent that all of its consequences have not been fully determined. However, it is already adding to fundamental knowledge of both tunneling and superconductivity and has opened a new approach to the construction of versatile, microminiature electronic components," according to Dr. Guy Suits, GE vice-president and director of research. "For example, it may be possible to make—in an entirely new way—a simple device that could function as a switch, diode, negative-resistance diode, triode, resistor, or capacitor," Dr. Suits said.

Electron Tunneling

The use of electron tunneling in electronics has received recent attention in connection with the new semiconducting tunnel diode. However, tunneling occurs in a broader class of materials than semiconductors. In Giaever's discovery, tunneling occurs through the simple barrier of an insulating film, rather than through the charge depletion region of a semiconductor p-n junction, as in the case of the tunnel diode.

The tunneling of electrons through thin insulating layers can be understood by thinking of the charge-carrying electrons not as particles, but as waves. When these charge-carrying waves strike a barrier (such as would be imposed by an insulator), virtually all of them will be reflected back from the barrier. There is a certain small probability, however, that a portion of the waves will pass through the barrier if it is thin enough. If a conductor is present on the other side, the presence of these tunneling waves may be detected as current. Despite the small probability of waves tunneling rather than reflecting, the number of the waves is so large that a substantial current may flow because of the effect.

Certain conditions must prevail for electron tunneling to be significant. If two plates of metal are separated by a good insulator, they form a capacitor, or condenser. Current does not flow through the insulator, even if it is as thin as a ten-thousandth of an inch. However, if the insulator is made even thinner, say from 10 to 100 atoms thick, the probability of electrons getting through the barrier becomes sufficient for a measurable current to flow. At relatively low voltages, the current induced by tunneling is proportional to the voltage, just as it would be if the insulator were an ordinary resistance element. That is, as higher voltages are applied, the current increases.

Giaever's Experiment

In experimenting with tunneling through ultra-thin insulating films, Giaever found an unexpected effect when one of the conducting films was a superconductor. Instead of a straight line graph showing that the current increased proportionally with the voltage, an S-curve was produced, indicating that an effect similar to that in the tunnel diode might be involved. Giaever quickly followed up this lead and found that a region of "negative resistance"—in which the current decreases with increasing voltage—could be observed if both metal films were superconducting.

This effect is the result of the fact that certain energy levels in a superconductor are "forbidden" to electrons. Any electrons in one metal film that have energies equal to "forbidden" energies in the other metal film cannot tunnel through the intervening insulating film. Therefore, these forbidden energy gaps in superconductors have a profound influence on the tunneling currents and lead to the unique behavior discovered by Giaever. Similar regions of negative resistance were previously observed in tunnel diodes.

This unpredicted finding has important implications for theories about superconductivity and about tunneling. From the practical standpoint, the discovery may become important by making possible a new family of devices unequalled for their small size, and versatility.

Most of Giaever's experiments have been with films of aluminum, lead, indium, and tin, all of which become superconductive at near liquid helium temper-

A LABORATORY SAMPLE used in studies of superconductivity and the tunneling effect is held by Ivar Giaever whose recent discoveries have advanced knowledge of these fields. The functioning portion of the device consists of the point at which the two metal strips cross.

atures. A considerable number of other metals are expected to exhibit the same effect. In almost all of the experiments, aluminum oxide was the insulating layer, although Giaever has obtained proof of tunneling through tantalum oxide, niobium oxide, and nickel oxide as well.

Potential Applications

One of the primary advantages of any device incorporating the effect discovered by Giaever is the possibility of changing the device's characteristics with a magnetic field. This is the result of a well-known property of superconductors: they can be changed to the normal state—i.e., made nonsuperconducting—by a sufficiently strong magnetic field. Thus, by varying a magnetic field, one or both of the superconducting films can be changed to the normal state, with a consequent change in operating characteristics of the device. This is why it may be possible for the device to function as a switch, diode, negative-resistance diode, triode, resistor, or capacitor.

Other potential advantages of devices based on the new effect would be extremely small size, low power requirements, and cheapness of fabrication. Since the devices would be made simply by depositing metal and insulating layers on a suitable substrate, it would be possible to deposit complex circuits involving hundreds of active components in one operation. This would result in a very large reduction in cost from present methods of fabricating and assembling complex circuits, and would make possible a comparably large reduction in size. The extremely low power dissipation—with only a small amount of heat generated—makes possible packing of the microminiature elements at a density many times greater than is possible with present semiconductor components.

A great deal of applied research and development will be required to evolve practical devices based on this new concept. Also, the requirement of cryogenic temperatures for the suggested new components may be a handicap, but this is not expected to be too serious for many uses. Small liquid helium refrigerators are available, and the low power dissipation of the devices may make cooling requirements actually less critical than for large, compact arrays of present components. In general, cryogenic technology is improving and growing.

Scientific Importance

The discovery of these new, previously unsuspected effects is making an important contribution to fundamental scientific knowledge of both superconductivity and tunneling. One of the basic problems of superconductivity is why some materials are superconductors and others are not. The experiments Giaever has designed are contributing data that may prove useful in solving this problem. Moreover, solid-state physicists now find it necessary to develop the theory of electron tunneling beyond the previous state of understanding—which was sufficient to explain tunnel diodes—in order to explain fully these new results. In addition to Ivar Giaever, other scientists of the General Electric Research Laboratory are actively engaged in this area of research, including Drs. John Fisher, W. A. Harrison, C. P. Bean, V. L. Newhouse, and Mr. Karl Megerle. It is anticipated that new discoveries may be made as their work continues.

Similar Research at ADL

Physicists at Arthur D. Little, Inc., (ADL) have also discovered the negative resistance phenomenon, which they expect will lead to the development of a whole new family of simply constructed components compatible with present low temperature electronic circuits such as cryotrons. The new devices, called "tunneltrons," may extend the range of cryogenic circuitry to include low-noise amplifiers. high-frequency oscillators, and new types of switches and memory devices usable in computers.

According to ADL, chief among the advantages that devices based on the new discovery promise over tunnel diodes is the ability to control negative resistance and hence the operation of a device by applying a magnetic field. Another advantage is the extreme ease of manufacture and the great flexibility this allows the circuit designer since the metal-dielectric-metal sandwiches are made by standard vacuum evaporation techniques. EE

New British Brain Is "Semiliterate"

A new, almost human, and already semieducated robot with ability to see, to read, to write, and even to talk, is being built in London, England.

What sort of accent will it have? It will be more mouse than Oxford or cockney—it will communicate by squeaks of varying pitch.

Forty times larger than the small 100-cell 9-photocell brain developed by Dr. W. K. Taylor of the University of London's engineering staff, which has served as a model, the new robot will be able to do much more than respond to simple geometrical shapes and alphabetical symbols.

"We hope," said Dr. Taylor, "that the 'big brain' will be able to recognize people and faces."

This might mean it could be turned into a 1-man robot, owing sole allegiance to its master and refusing to react to strangers.

The 'big brain' will have 4,000 cells (to man's 10 billion) and an "eye" of 100 photoelectric cells. It should be ready for action in about a year.

It is being built on the same principles as the earlier, smaller model. Both differ radically from the mechanical computers generally in use.

"They are special machines for solving the particular sorts of problems that concern an animal or human," Dr. Taylor explained.

Built into them is a selector which can decide which problems are important and

Future Meetings of Other Societies

SAE, Annual Meeting, Jan. 9-13, Cobo Hall, Detroit, Mich., Society of Automotive Engineers, 485 Lexington Ave., New York 17, N.Y.

Heat Exchange Institute Meeting, Jan. 12-14, Seaview Country Club, Absecon, N.J. National Electrical Manufacturers Association, 155 E. 44th St., New York 17, N.Y.

AAS, 7th Annual Meeting, Jan. 16-18, Sheraton-Dallas Hotel, Dallas Texas. American Astronautical Society, Box 14-1, Grand Prairie, Texas.

ISA Winter Instrument-Automation Conference & Exhibit, Jan. 17-19, Sheraton-Jefferson Hotel and Kiel Auditorium, St. Louis, Mo. W. H. Kushnick, Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

AIME, 3rd Mechanical Working Conference "Bar and Shaped Products," Jan. 18, Penn-Sheraton Hotel, Pittsburgh, Pa., American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 29 W. 39th St., New York 18, N.Y.

Industrial Heating Equipment Association, Inc., Jan. 23-24, Dearborn Inn, Dearborn, Mich., Air-Conditioning and Refrigeration Institute, 1346 Connecticut Ave., N.W., Washington 6, D.C.

IAS, 29th Annual Meeting, Jan. 23-25, Hotel Astor, New York, N.Y., Meetings Dept., Institute of the Aerospace Sciences, 2 E. 64th St., New York 21, N.Y.

12th Annual Plant Maintenance & Engineering Show, Jan. 23-26, International Amphitheatre and Palmer House, Chicago, Ill. Clapp & Pollak, Inc., 341 Madison Ave., New York 17, N.Y.

Gaillard Seminar on Industrial Standardization, Jan. 25-27, Engineering Societies Building, 33 W. 39th St., New York 18, N.Y. Dr. J. Gaillard, 135 Old Palisade Rd., Fort Lee, N.J.

SPE, 17th Annual Technical Conference, Jan. 24-27, Shoreham Hotel, Washington, D. C. R. D. Forger, Society of Plastics Engineers, Inc., 65 Prospect St., Stamford, Conn.

ASTM, Committee Week, Jan. 30-Feb. 3, Netherland-Hilton Hotel, Cincinnati, Ohio. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

8th Cleveland Electronics Conference, Jan. 31-Feb. 2, Engineering Center, Lapine Enterprises, Cleveland, Ohio.

Institute of Radio Engineers, Winter Convention on Military Electronics, Feb. 1-3, Los Angeles, Calif. Dr. J. J. Myers, Hoffman Electronics Corp., Military Products Div., 3715 South Grand Ave., Los Angeles 7, Calif.

American Rocket Society, Solid Rocket Conference, Feb. 1-3, The Hotel Utah, Salt Lake City, Utah. R. D. Geckler, Aerojet-General Corporation, P. O. Box 1947, Sacramento, Calif.

Overseas

10th Electrical Engineers Exhibition, Mar. 21-25, Earls Court, London. Electrical Engineers (ASEE) Exhibition Ltd., 6 Museum House, 25 Museum St., London, W. C. 1, England.

The Engineering, Marine, Welding & Nuclear Energy Exhibition, Apr. 20-May 4, London. A. Seligman, 9 Malcolm Rd., London, S.W. 19, England.

which are not. This means they can do many things a computer cannot. One of them, the inventor hopes, is the ability to learn how to read script.

Dr. Taylor, who conceived and built the small brain, and who is co-operating on the larger robot with the College's Professor of Anatomy, Prof. J. Z. Young, said that it is primarily a research tool.

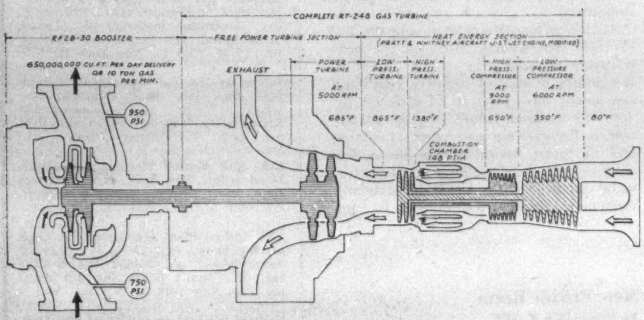
Prof. Young will use it to learn more about how the human brain works, including how to train it better and how to detect the onset of, and avoid a mental breakdown. **EE**

Jet-Driven Gas Turbines For Industrial Power Needs

INDUSTRY'S first harnessing of aircraft jet thrust as a source of stationary power began recently at Possum Trot in the hills of Kentucky near Clementsville.

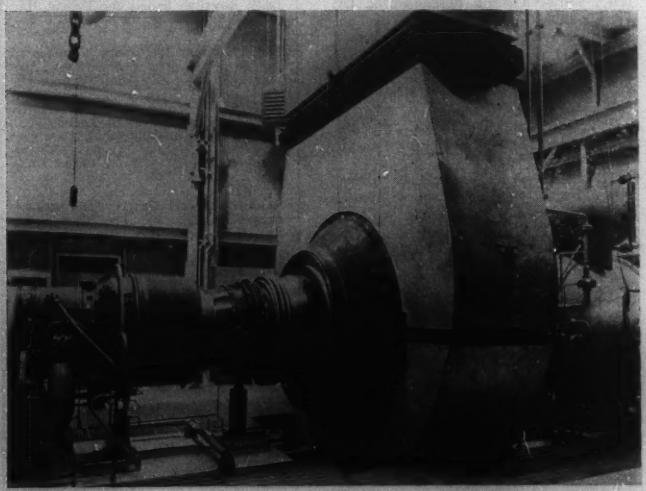
A new type of gas turbine, using an adapted aircraft jet engine, is now pumping about 600 million cubic feet of natural gas a day in the pipeline compressor station of the Columbia Gulf Transmission Company, a subsidiary of the Columbia Gas System.

COOPER-BESSEMER RT-248 GAS TURBINE DRIVING COOPER-BESSEMER RF2B-30 PIPELINE BOOSTER
10,500 B.H.P.
(AS INSTALLED ON MAIN LINE OF COLUMBIA GULF TRANSMISSION COMPANY AT CLEMENTSVILLE, KENTUCKY)



OPERATING DIAGRAM

THIS VIEW (below) inside the new compressor station of the Columbia Gulf Transmission Company near Clementsville, Ky., shows the Cooper-Bessemer *RT-248* Gas Turbine and associated facilities. The adapted Pratt & Whitney Aircraft J-57 jet engine (*foreground*) is the heat energy source which supplies raw thrust to turn the specially designed turbine (characterized by the tall exhaust "chimney"). The turbine is linked to the large centrifugal compressor (*background*), also specially designed. The *RT-248* develops 10,500 rotative hp and provides this compressor station with pumping capacity to move about 600 million cubic feet of natural gas a day through the Columbia Gulf pipeline, which runs from Rayne, La., to near Ashland, Ky.



This represents the first successful mating of an aircraft jet engine to industrial power needs.

A revolutionary prime mover, the *RT-248* gas turbine develops 10,500 rotative hp and weighs 84,000 pounds, about one sixth the weight of a conventional gas turbine unit. It is the first of a family of jet-powered gas turbines to be rated from 350 to 15,000 hp. The power plants are expected to find widespread use in the natural gas, petroleum, and petrochemical industries, in electric power generation, and in marine applications.

Designed by The Cooper-Bessemer Corporation of Mount Vernon, Ohio, the new gas turbine uses as its heat energy source a Pratt & Whitney Aircraft J-57 jet engine, adapted to run on natural gas.

To Columbia Gas, the new power unit represents another step in its search to find ways to reduce costs and raise operating efficiency for the system's natural gas customers.

Almost 85 tons lighter than conventional gas turbines of equal power and efficiency, it is designed to lower installation, maintenance, and operating costs substantially.

Its lightweight, 4,000-pound jet engine section, with 10-to-1 compression ratio, requires no regenerating system. Nevertheless, thermal efficiency equals or exceeds that of all other gas turbines in operation today.

Regenerating systems circulate hot gases to salvage heat energy otherwise wasted, and are essential in conventional gas turbines to reach acceptable efficiency. They involve extensive equipment, components, and piping.

The *RT-248* requires less than half the space, relatively simple foundationing, and much lighter crane facilities than regenerated gas turbines of equal power. Thus, size and cost of a station building are greatly reduced.

Less than 4 hours are required to remove the jet engine section and replace it, ready again for operation. Conventional systems require weeks of shut down for overhaul.

The adapted J-57 jet engine never reaches jet "take off" speeds, temperatures, or stresses. In industrial application, it will operate at or below low stress flight cruising speed. Results are low running temperatures and prolonged service life.

Designers estimate the jet section will run at least 8,000 operating hours between overhaul, equivalent to a year's continuous operation.

Raw thrust of the J-57 jet section is converted to rotative power by a specially designed heavy-duty free turbine, completing a team that comprises the new *RT-248* gas turbine. In this installation, the J-57 drives a Cooper-Bessemer centrifugal compressor which pushes natural gas through the Columbia Gulf pipeline. **EE**

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Signal Corps Radio Tubes Play Well 42 Years Later

Radio tubes like those used in the first wireless telephone conversation between an Army airplane and the White House in November 1918 still work fine, it was discovered in a Pentagon ceremony recently.

A radio equipped with these 42-year-old tubes was played at its presentation as a historical memento to the U.S. Army Signal Corps. Called "VT-1's" (vacuum tube number one), the antique bulbs matched the performance of present tubes in reproducing voice and music. They were connected to a small broadcast receiver and arranged in modern circuits for the demonstration. The music quality compared with high-fidelity amplifiers.

The radio with the historic old tubes was presented to the Army's Chief Signal Officer, Major General R. T. Nelson, by W. H. Doherty, manager, patents licensing, Western Electric Company. Mr. Doherty, whose company produced these first military vacuum tubes for the Signal Corps during World War I, is the inventor of another circuit, the Doherty amplifier.

Forty-two years ago, on the same date, the now antiquated VT-1 was used in the first air-to-ground radio gear demonstrated by the Army and Western Electric for President Wilson. Standing on the White House lawn, the radio set on a bench near him, President Wilson took the microphone and talked with the Army pilot circling overhead.

These still usable VT-1's were the first mass-produced vacuum tube. They helped chart the course of modern electron tube technology. The emission elements now used in receiving tubes are still oxide-coated.

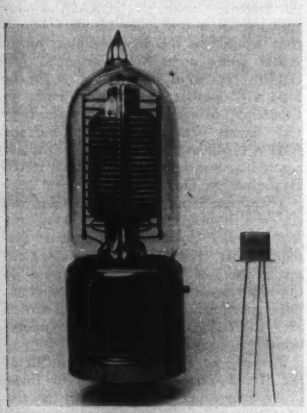
More than four decades after the historic air-to-ground conversation of one President, transistors, which helped replace many tubes, figured in the first space message sent by another President—President Eisenhower. A handful of tiny transistors manufactured for the Army Signal Corps by Western Electric found their way into America's first communication satellite, Project Score, which broadcast the President's Christmas message in 1958.

Earlier that year, other transistors for the Army—*2N195*—amplified the first U.S. signals from space to earth as the Army's Explorer I orbited the world.

These tiny transistors in space are a modern echo of the old VT-1's in an Army biplane circling the White House. The time-span between—measured by the still useful life of the old tubes—emphasizes American military and civilian progress in electronics.

Over 300,000 of these tubes were manufactured in 1917 and 1918. Although Western Electric had built tubes starting in 1912 and used them in the first transcontinental telephone circuits in 1915, the manufacture amounted to only about 200 per week on a laboratory basis. After obtaining a contract in January 1917, the company was producing 15,000 per week by August 1918, a remarkable figure even in today's mass producing economy.

The Signal Corps still used these tubes in the early twenties, but many were declared surplus and sold to the public when radio was in its infancy. Early radio builders and DX'ers (long distance listeners) used these tubes extensively to construct their sets. Many surplus dealers say these tubes were popular with radio experimenters as late as World War II when tubes were difficult to obtain. One dealer said he priced these tubes at $8 each at that time, although the cost to the Signal Corps has been estimated at $4 to $5 each in World War I. **EE**



RADIO TUBES, like that above, which were used in the first wireless telephone conversation between an Army airplane and the White House in 1918, still work fine 42 years later. The vintage tubes were used in a working radio presented to the U.S. Army Signal Corps on November 21, the 42nd anniversary of the historic air-to-ground conversation between President Wilson and the Army pilot circling overhead (*right*). The first mass-produced vacuum tubes, the antique bulbs were produced for the Signal Corps in World War I. In a demonstration at the Pentagon they matched the performance of modern tubes. The tiny transistor shown above, also made for the Signal Corps by Western Electric, found its way into the world's first communication satellite, Project Score, which sent President Eisenhower's Christmas message in December 1958. The radio with the now-antiquated but still working tubes was presented to the Army's Chief Signal Officer, Major General R. T. Nelson, as a historical memento by W. H. Doherty, manager, patents licensing, Western Electric Company. *U.S. Army Photograph*

World Adopts New Standard of Length

At 6:00 p.m. Paris time on October 14, 1960, the world adopted a new international standard of length—a wavelength of light—replacing the meter bar which has served as the standard for more than 70 years. The announcement was made from Paris by Dr. A. V. Astin, director of the National Bureau of Standards (NBS), U. S. Department of Commerce. The action was taken by the 11th General Conference on Weights and Measures.

Dr. Astin headed the American delegation to the conference. The delegation also included Louis Polk, president, Sheffield Corporation; Elmer Hutchisson, director, American Institute of Physics; A. G. McNish, chief, Metrology Division, NBS; T. H. Osgood, United States scientific attache, London, and Martin Van Heuven and Benjamin Bock, U. S. State Department.

Other actions taken by the conference

NBS scientist adjusts a krypton-86 lamp in its liquid nitrogen bath. The wavelength of the orange-red light emitted by the lamp has been adopted as the International Standard of Length. The lamp is operated at the triple point of liquid nitrogen, 63 K, to increase the stability of the standard wavelength.

THIS platinum-iridium bar, Prototype Meter Number 27, has been replaced as the national standard of length by the wavelength of the orange-red light emitted by the krypton isotope 86. The meter bar, shown here with the national standard of mass, Prototype Kilogram Number 20, will remain important as a secondary standard because of the ease with which it can be used for certain types of measurements.

included the establishment of a central facility at the International Bureau of Weights and Measures for international co-ordination of radiation measurements and confirmation of a new definition of the second of time.

The new definition of the meter as 1,650,763.73 wavelengths of the orange-red line of krypton 86 will replace the platinum-iridium meter bar which has been kept at Paris as an international standard for length since 1889 under the Treaty of the Meter.

While not of great concern to the man in the street, these actions of the General Conference are of great importance to those engaged in precision measurement in science and industry. For many years the world has relied on a material standard of length—the distance between two engraved lines on the International Meter Bar kept at Paris. Duplicates of the International Standard were maintained in the standards laboratories of other countries of the world. From time to time it was necessary to return these duplicates to Paris for recalibration, and occasionally discrepant results were obtained in these recalibrations. Also, there was doubt in the minds of some scientists regarding the stability of the international meter bar. The new definition of the meter relates it to a constant of nature, the wavelength of a specified kind of light, which is believed to be immutable and can be reproduced with great accuracy in any well-equipped laboratory. Thus, it is no longer necessary to return the national standards of length to Paris at periodic intervals in order to keep length measurements on a uniform basis throughout the world. Also, it is possible to measure some dimensions more accurately in terms of the new definition than was possible before. The meter bars which have served as standards of length throughout the world for over 70 years will not be discarded or placed in museums because of this decision, the conference said. They will remain important because of the ease with which they can be used for certain types of measurements.

This new definition of the meter will not materially change the measurement of length nor in any way the relation between the English and metric units. Careful experiments performed at the NBS by the team of A. G. Strang, K. F. Nefflen, J. B. Saunders, B. L. Page, and D. B. Spangenberg immediately prior to the meeting of the conference confirmed that the wavelength standard and the metal standard are in satisfactory agreement. The inch now becomes equal to 41,929.399 wavelengths of the krypton light.

Similar measurements performed by the National Research Council in Canada, by Dr. K. M. Baird and his associates, are in substantial agreement with the NBS results. They all show that the distance from a point in New York to a point in Washington would be altered by less than 3 inches, as measured in terms of the old metal standard and the new wavelength standard. However, by adoption of the new definition, the standard of length which has been used by spectroscopists for the past 50 years is brought into agreement with that used in other branches of science, thus increasing the unification of systems of measurement throughout the scientific world. Although the conferees recognized that the new definition may have the effect of shortening the meter, the amount of shortening will be less than 1/5,000 part of the thickness of one thin dime.

The establishment of a central international facility for measurement of X rays, radioactive isotopes, and neutrons will assure that all nations of the world will be able to make co-ordinated measurements of these radiations. To accelerate the planning of this major effort to establish world-wide standards of radiation measurement, the Ford Foundation has made a grant of $32,500 to the International Bureau of Weights and Measures which was accepted by the conference. The conference confirmed the action of the International Committee on Weights and Measures in defining the second of time as 1/31,556,925.9747 of the tropical year 1900 instead of 1/86,400 part of the mean solar day, and discussed the possibility of using atomic vibrations as standards for measuring time intervals.

EE

U.S., Canada Now Under Partial Protection of BMEWS

The first of three major bases of the U. S. Air Force's Ballistic Missile Early Warning System (BMEWS) went into operation recently at Thule, Greenland. The system would provide at least 15 minutes of warning to United States and Canadian air defense and retaliatory forces and civil defense agencies in the event of a ballistic missile attack across the top of the world.

The battle staff of the North American Air Defense Command (NORAD) saw for the first time the types of alert signals that would be the first warning of an ICBM attack upon North America. Special displays went into operation in the NORAD Combat Operations Center in Colorado Springs, Colo., in response to test signals sent southward from the BMEWS site at Thule. Similar displays reacted at Strategic Air Command (SAC) Headquarters, Omaha, Nebr.

The operational responsibility for the site was transferred to NORAD by the Air Materiel Command's Electronic Systems Center. The Electronic Systems Center is the Air Force agency responsible for implementing the BMEWS program. Other portions of BMEWS will be turned over to NORAD as they become operational.

The site at Thule, 600 miles north of the Arctic Circle, is the first of three super long-range radar stations in the BMEWS system. The warning from the system will provide NORAD with not less than 15 minutes to alert the nation's air defense forces and Civil Defense Headquarters.

SAC in turn will have the same number of vital minutes to "scramble" additional retaliatory bombers and missiles. The BMEWS alert will increase the deterrent power of the nation's defense and retaliatory forces by increasing their effectiveness to react to an ICBM raid. An ICBM traveling across the pole at 15,000 mph requires only 30 minutes to cover its 6,000-mile trajectory.

The BMEWS Program is part of a continental air defense system, and its warning will be passed to defense agencies in Canada as well as the United States. NORAD is a bi-national joint command, staffed by members of all branches of Canadian and American armed forces.

The BMEWS site at Thule will provide radar coverage of the polar routes that would be traveled by the bulk of any ICBM force carrying out a mass raid against North America. The second and

third stations, in Alaska and England, respectively, will cover the flanking approaches to the continent.

They are being rushed to completion with the Alaska site due to be operational in the summer of 1961 and English site at a later date.

The BMEWS system at Thule represents a $500 million investment. The entire BMEWS system will cost approximately $1 billion. Despite the difficulties of arctic weather and long transportation lines, and the need for a great deal of creative engineering behind the design of equipment, the BMEWS site at Thule has been completed exactly on schedule.

The Thule site consists of four detection radars with ranges in excess of 3,000 miles. Returns from the radars are automatically fed into electronic computers that calculate in thousandths of a second the course and speed of the missiles. The information is then passed southwards to NORAD and SAC Headquarters over a complex communications network. A central computer at Colorado Springs combines the data from the three forward sites and activates the display panels in the Combat Operations Centers. From the time of the spotting of the enemy missile in the sky until the warning is displayed at NORAD and SAC is a matter of not more than 10 seconds.

The BMEWS displays will indicate to the NORAD and SAC battle staffs the size of the raid and the courses and speeds of the missiles. An evaluation of the seriousness of the raid will be indicated on a numerical scale.

To obtain radar ranges in excess of 3,000 miles, all BMEWS equipment has had to be engineered to king-size proportions. Reflecting antennas measure 165 feet high by 400 feet long. Power amplifier tubes for the transmitter stand over 10 feet high.

The Thule site has been constructed under the most adverse weather conditions. All equipment has been engineered to withstand arctic winds of 185 mph and temperatures as low as —65 F.

To insure that BMEWS will not be out for repairs during those critical 30 minutes required to carry out an ICBM attack, all equipment has had to be designed for nearly 100% reliability. Where this was mechanically impossible, one of two methods was used. Either the equipment was constructed in snap-in snap-out modules for rapid repair-by-replacement or the equipment was installed in duplicate.

The communications channels from Thule to NORAD Headquarters, for example, follow two separate routes, and the communications techniques and equipments are different for each of the several legs along the routes. For example, where an undersea cable is used for one communications channel, a radio link is used for the other. Atmospheric conditions which might affect one channel, therefore, would not affect the other.

The industrial team responsible for the production and installation of BMEWS equipment has been headed by the Radio Corporation of America as system prime contractor, with the Western Electric Company serving as a separate prime contractor for rearward communications. Chief subcontractors for BMEWS include the General Electric Company for the detection radars, Sylvania for the data-processing equipment, and the Goodyear Aircraft Company for the fabrication of the special tracking radar antenna, pedastal, and radome. The tracking radar will be installed at the English site. EE

New Facilities Test Rocket Engines

Rocket-engine facilities to data-test motors that will power supersonic airplanes of the future and drive missiles into space, have been completed at the U.S. Air Force Flight Test Center, Edwards Air Force Base, Calif., by ITT Laboratories, Nutley, N. J., domestic research division of International Telephone and Telegraph Corporation.

Designed by ITT Laboratory engineers and built under their supervision, in cooperation with the U.S. Air Force, the complex of five cells has the complete instrumentation necessary to measure and record temperature, pressure, force, and any other factor of the horizontally mounted engines.

Each cell area is built to support rockets developing up to 100,000 pounds of thrust, and includes provision for visual, camera, and television observation of all test programs.

The single units are 28 feet wide by 40 feet long, formed by 2-foot-thick reinforced concrete baffle walls and a common personnel-instrument tunnel joining all cells.

Viewing ports, consisting of laminated plate glass, 6 inches thick, are provided in the baffle walls and tunnel wall. Bank-vault-type doors provide access from the tunnel to the cells.

For extremely hazardous tests, 3-inch-thick steel curtains are drawn over all viewing windows to prevent damage. Engineering personnel withdraw from the tunnel to a central control building, and observe the test on closed-circuit television.

This central control building houses all the instrumentation and control equipment necessary to perform the operation, safety, and test functions and is capable of "patch-switching" any desired combination of instruments to any of the test areas being used. Any combination of five engines can be tested.

Because of the experimental nature of the work, a fire-control and personnel protection system is a vital part of the facility. A test area water-deluge system as well as personnel showers and eye-wash facilities are provided.

Since highly volatile liquid propellants are being used during a test, a vital part of the facility is the hydraulic distribution system that supplies the propellants, water, and high-pressure helium and nitrogen. The design ensures that the propellants mix only in the test cells.

A. M. Levine, vice-president, missile and space systems, under whose direction the work was accomplished, has called this new Air Force facility, "an example of electronic and mechanic engineering in which flexibility of operation is the central theme of the complete design." EE

Fused Silica Mirrors For Astrometric Telescope

Two giant mirrors of fused silica—one the largest ever made—will be used in a new precision telescope to pinpoint distances and movements of the faintest stars.

AIR FORCE engineers and technicians gather around strip-chart recorders in the central control facility of a rocket engine test cell designed and built at Edwards Air Force Base, Calif., under contract with ITT Laboratories, domestic research arm of International Telephone and Telegraph Corporation. The moment the rocket's roar dies away the scientists can turn to the permanent record to determine how well the test went.

Corning Glass Works will produce the mirror blanks. One disk will be 62 inches in diameter. The other will be a 35-inch piece.

They have been ordered for a 60-inch astrometric telescope to be constructed by the U. S. Naval Observatory at the Observatory's Flagstaff Station near Flagstaff, Ariz.

Size of the 62-inch mirror dwarfs the 36-inch fused silica disk made by Corning for the balloon telescope that will be sent aloft in 1961 under Project Stratoscope II. (See *Electrical Engineering*, August 1960, p. 703.)

The 62-inch mirror will be the primary reflective disk in the Flagstaff telescope. The mirror will be 10 inches thick. The 35-inch mirror will be 5½ inches thick and will serve as the secondary reflective piece in the telescope.

These mirrors will be installed in the first large reflector telescope designed expressly for astrometric work. The instrument will be used to determine distances and motions of faint stars up to 100 light years or 600 trillion miles from the solar system.

In addition to basic research in positional astronomy, the telescope will enable astronomers to observe deep space probes and distant artificial satellites, according to the U. S. Naval Observatory.

The "seeing" capacity of the telescope will increase a hundred times the ability of man to measure the motion and determine the position of celestial bodies, both natural and artificial. The telescope is expected to provide new information on the candle power of the red and white dwarf stars as well as important clues to the physical properties and evolutions of these objects.

Success of the program requires photographs of unprecedented clarity and detail. Observatory officials said the telescope was designed to provide such precise data.

Fused silica was selected for the mirrors because the material is virtually unaffected by temperature variations, assuring distortion-free images. Fused silica has a thermal expansion rate one-fourth that of the borosilicate glass used in many telescopes.

The two mirror blanks will be made at Corning's Fused Silica Plant at Bradford, Pa. Production is expected to take between 6 and 8 months.

Developed by Corning research scientists, fused silica is one of the purest man-made substances known. Impurities average less than one part per million. The material is used for lenses, prisms, and lightweight telescope mirrors in aircraft. Fused silica windows are used in wind tunnels for testing of missiles.

EE

Remote Document Retriever Being Evaluated by the Navy

A new concept in remote copying operations, printing more than a square foot of information per second, and transmitting it between two distant points, was introduced at the Pentagon, Washington, D.C., recently. Called the Remote Document Retriever, the new system was developed by the Hogan Faximile Division of the TELautograph Corporation.

The prototype of the system was displayed at the Pentagon Concourse by the Bureau of Ships, U. S. Navy.

The U. S. Navy has purchased the huge prototype outright; however, compact versions suitable for industrial and commercial uses will be made available on a lease basis, with rentals within the range of the average small to medium business operation.

Basically, the system consists of any number of sending and receiving units. An official of an organization, from any remote point, may ask for anything in the central microfiles. He may obtain a full-size copy of the material instantaneously.

Since vast amounts of information are stored on microfilm by industry, public service, and Government agencies, the retrieval of this information in printed form is extremely important. The establishment of a central filing room, no matter how far-flung and complicated the organization, has become an extremely desirable management objective.

The Document Retriever provides a complete, rapid, low-cost transmission of information in large quantities between home office and branch offices on a direct minute-to-minute basis. It also assures the preservation of the original material since it never leaves the central files.

To illustrate the speed of the new system, a 480-page book can be sent from New York to Los Angeles in a matter of 4 minutes. The equipment will make and transmit from one to an unlimited number of copies.

Although it has application in any area where high-speed high-volume transmission of graphic information is necessary, the Armed Forces and other Government agencies are particularly interested in the equipment and its versatility in handling both engineering drawings and standard documents. These qualities also make it practical for many industrial uses.

The new Document Retriever employs a flat-bed continuous scanner capable of scanning all kinds of documents, charts, and graphs, and a continuous multiple stylus facsimile recorder which remotely reproduces the scanned material on electronic recording paper. The image is conveyed from the scanner to the receiver by either coaxial cable or microwave (radio) transmission network.

The equipment employs the latest developmental features including transistorized circuitry and regulated solid-state power supplies.

EE

THIS transmitter-scanner (above) of the Remote Document Retriever, built for the Bureau of Ships, U. S. Navy, by the Hogan Faximile Division of the TELautograph Corporation, can send the complete text of a 480-page book to a recorder (right) located miles away in only 4 minutes. Although the scanner transmits from microfilm, the document is received full size.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, *Electrical Engineering* reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, doube-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Tribute to Sperry

To the Editor:

In *Electrical Engineering* for October, I enjoyed Bassett's story about Elmer A. Sperry (pp. 808-11).

On p. 809, I read that Sperry graduated from the Cortland Normal School in 1879. On p. 808, it says the school was established in 1886. One more tribute to Sperry's greatness—to have been able to graduate from a school 7 years before it was started.

Very best regards.
A. D. MOORE

(Department of Electrical Engineering, The University of Michigan College of Engineering, Ann Arbor, Mich.)

EDITOR'S NOTE: It has been learned that the Cortland Normal School was founded in 1866, but don't blame our proofreader; it was 1886 in the copy.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

THE ROLE OF NUCLEAR PROPULSION IN MERCHANT SHIPPING. Edited by G. Brown, Jr., and W. J. Smith. Atomic Industrial Forum, Inc., 3 E. 54th St., New York 22, N.Y., 1960. 172 pages, 8¼ by 11 inches, paper. $7.50. The proceedings of the April 1960 meeting sponsored by the Atomic Industrial Forum, presenting papers and discussions on economic potentials for nuclear merchant ships, safety and liability problems, propulsion systems, plans of shipbuilders and operators, and activities in the field abroad.

STATISTICAL THEORY OF COMMMUNICATION. By Y. W. Lee. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1960. 509 pages, 6 by 9¼ inches, bound. $16.75. This college-level introduction covers essentially all the basic elements of linear systems in the statistical theory of communications. Discussion in the final two chapters of orthonormal functions and the orthonormal representation of linear systems, important in the statistical theory of optimum nonlinear systems, is the only inclusion of nonlinear aspects. The text covers harmonic analysis, probability, random variables, ensembles, distributions, averages, densities, correlation functions, sampling theory, the fundamental relations of a linear system, and optimum linear systems, filtering, and pre-

Library Services

ENGINEERING Societies Library books, except bibliographies, handbooks, and other reference publications, may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint or a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, 29 W. 39 St., New York 18, N. Y.

SYMPOSIUM ON SPECTROSCOPY. Published as ASTM Special Technical Publication no. 269 by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 245 pages, 6¼ by 9¼ inches, bound. $7. This volumes contains 16 papers presented at the symposium dealing with such topics as atomic, X-ray, infrared, molecular, ultraviolet, magnetic resonance, and electron paramagnetic resonance spectroscopy, flame photometry, infrared and spectroscopic analysis, and applications in geochemistry, petroleum technology, and other fields. Also included is a nonsymposium paper dealing with application of spectrography to the analysis of water-formed deposits.

LA THEORIE DES GAZ NEUTRES ET IONISES. By E. W. Montroll and others. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1960. 469 pages, 7 x 9¾ inches, bound. $17.50. This volume contains material presented at the ninth (1959) session of the summer school in theoretical physics at the University of Grenoble, France. The nine sections are self-contained, and usually include extensive bibliographies. Five sections are by American scientists, and discuss statistical mechanics of interacting particles; plasma in a strong magnetic field; asymptotic theory of systems of ordinary differential equations; Landau damping; and plasma transport theory. One section from the Netherlands presents lectures in English on statistical mechanics of nonequilibrium phenomena. The remaining contributions are from France, and deal with the microscopic theory of ionized gases, electromagnetic waves in plasmas, and the role of plasmas in astrophysics.

THE ARC DISCHARGE. By H. de B. Knight. Chapman & Hall Ltd., London, England, 1960. 444 pages, 5½ by 8¾ inches, bound. £3.3.0. This British book is concerned with the use of arc-discharge valves such as thyratrons, ignitrons, and excitrons for the control of electric power. It describes construction, operating characteristics, capabilities, limitations, service conditions, and behavior in miscellaneous rectification and control circuits. Also discussed are the physical processes involved inside the valves.

ENGINEERING ANALYSIS. By Wen-Hsiung Li. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1960. 362 pages, 6¼ by 9¼ inches, bound. $8.25. This is a treatment of mathematics entirely from the engineer's point of view. The topics covered are applications of integral and of differential calculus, vector algebra, ordinary differential equations, and the Fourier series. Numerical and graphic methods are given, emphasizing precision of results. Worked-out solutions are given for some problems, and answers are given for all.

NUTZENERGIE AUS ATOMKERNEN, Volume II. By K. R. Schmidt. Walter de Gruyter & Co., Berlin, Germany, 1960. 1336 pages, 7 by 9½ inches, bound. No price given. This second volume on the application of nucleat energy discusses radiation hazards and reactor shielding; reviews the problems of reactor operation and control; and includes chapters on reactor installation, raw materials, and economic and legal aspects. A list of both finished and planned reactors is appended with a historical survey of the field and an extensive bibliography.

OPTICS OF THE ELECTROMAGNETIC SPECTRUM. By C. L. Andrews. Prentice-Hall, Inc., Englewood Cliffs, N. J., 501 pages, 6¼ by 9¼ inches, bound. $12. This guide to general methods for solving problems of wave optics treats the properties of wave motion common to the whole electromagnetic spectrum. The introductory chapter gives the historical background of physical optics, and discusses the generation, detection, and properties of electromagnetic waves and radiation. The remaining chapters discuss the contributions of contemporary wave physics in wave propagation, superposition, interference, diffraction, dispersion and polarization, and developed techniques and theories such as Michelson's interferometer, Fraunhofer diffraction, Maxwell equations, and Fresnel diffraction. Prerequisites are a course in general physics, and one in elementary calculus.

PLASMA ACCELERATION. Edited by S. W. Kash. Stanford University Press, Stanford, Calif., 1960. 117 pages, 6¼ by 9¼ inches, bound. $4.25. This volume contains the nine papers presented at the Fourth Symposium on Magnetohydrodynamics sponsored by the Missiles and Space Division of the Lockheed Aircraft Corp. The emphasis is on the acceleration of plasma for space propulsion. The steady-state acceleration of plasma by crossed electric and magnetic fields, pulsed plasma accelerators utilizing energy from high-energy capacitor discharge, and the acceleration of ionized material by purely electrostatic means are considered.

PRINCIPLES OF CONTROL SYSTEMS ENGINEERING. By V. Del Toro and S. R. Parker. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1960. 686 pages, 6¼ by 9¼ inches, bound. $14.50 A treatment of feedback control systems at the senior-graduate level. The order of presentation reflects the historical development of each phase. The book covers the mathematical background, including classical and Laplace-transform solutions of linear differential equations, and time-domain, frequency-domain, root locus, and computer methods. The final chapter discusses the most significant recent advance, self-adaptive control systems.

THE PRINCIPLES OF SCIENTIFIC RESEARCH. By Paul Freedman. Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y., 1960. 228 pages, 5½ by 8¾ inches, bound. $3.50. This book is addressed primarily to the young scientist, and discusses what research is like as an activity and those who spend their lives carrying it out. Part 1 covers the development of the process of research, and its relationship with social change and available techniques. Part 2 describes the principles of research process, and part 3 surveys the support available for research. This new edition contains modifications to the first edition's Part 1, concerning biological topics, and an appendix to part 3 presenting up-to-date information.

PRINCIPLES OF SEMICONDUCTOR DEVICE OPERATION. By A. K. Jonscher. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1960. 168 pages, 5¾ by 9 inches, bound. $5. This book is a study of semiconductor devices based on carrier injection. Chapter I states without proof the fundamental facts of semiconductor physics. The remaining chapters present an account of transport laws for excess carriers, a complete theory of junction diodes including current flow at high and at very high densities, and the theory of carrier transport in inhomogeneous media. Transistor topics are discussed from this same point of view of the injection, transport and decay of excess carriers, and the operation of certain new devices is presented.

SPACE RESEARCH. Edited by H. Kallman Bijl. Interscience Publishers, Inc., 350 Fifth Ave., New York 1, N. Y., 1960. 1195 pages, 7 by 9¾ inches, bound. $24. This volume contains the Proceedings of the First International Space Science Symposium, held in Nice, France, January 1960, and sponsored by the Committee on Space Research of the International Council of Scientific Unions. Included are nearly 100 papers contributed by scientists from 18 nations, arranged in seven topical sections, as follows: the earth's atmosphere, the ionosphere, tracking and telemetering, solar radiation, cosmic radiation, interplanetary dust, the moon and the planets.

SYMPOSIUM ON HIGH-VOLTAGE CABLE INSULATION. Published as ASTM Special Technical Publication no. 253 by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1960. 39 pages, 6 by 9 inches, paper. $1.50. Three papers are included in this volume: "Paper for High-Voltage Cables"; "The Why and the How of Cable Oil Tests"; and, "The Utility Viewpoint on Cable Oils."

THE TESTING OF ELECTRICAL MACHINES. By L. H. A. Carr. Macdonald & Co., Ltd., London, England, 1960. 299 pages, 5¾ by 9 inches, bound. 50s. This book covers not only the actual techniques of testing, but also the purposes of the tests, the subsequent treatment of the data obtained, and the principles underlying the actions of the standard classes of machines concerned. Single-phase and 3-phase commutator machines are not included. British testing practice and British Standard Specifications are referred to only.

THE THEORY OF BRILLOUIN ZONES AND ELECTRONIC STATES IN CRYSTALS. By H. Jones. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1960. 268 pages, 6½ by 9 inches, bound. $9.50. This is an account of the "band theory"—the mathematics of the solution of the Schrödinger equation in which the potential energy has the symmetry properties of one or other of the crystallographic space groups. The seven chapters deal with the 1-dimensional periodical potential, Brillouin zones, the classification of electronic states and descriptions of point groups and special space groups, large zones in extended k-space, quantitative estimates of wave functions and energies, and spin-orbit coupling effects.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

FUEL CELLS—POWER FOR THE FUTURE. This technical and economic analysis of developments and opportunities in electrochemical fuel cells was originally written as partial fulfillment of the requirements of the degree of Master of Business Administration at the Harvard Business School. The research group, composed of five engineers and four liberal arts graduates, investigated the developments and opportunities in the field of electrochemical fuel cells, a source of power which lately has attracted great attention because of the significant commercial impact its introduction could have upon the economy. While this study, made under the direction of Prof. G. F. Doriot, is economic and engineering in nature, it is directed not only to a technical audience, but also to the general business audience. Chapters include: Fuel Cells—Power for the Future; A Technical Review of the Electrochemical Processes and Limitations of Fuel Cells; Fuel Prospects and Considerations; Criteria for Fuel Cell Evaluation; Performance and Economic Analysis of Present and Expected Fuel Cell Systems; The Fuel Cell Mechanical Power System; Fuel Cells in Mechanical Power Applications; Fuel Cells in Electrical Power Applications. The report is available from Fuel Cell Research Associates, P. O. Box 157, Cambridge 38, Mass., for $18.75.

ELECTRONICS AND ELECTRICITY FOREIGN TRANSLATIONS. The following eight translations of foreign technical literature on electronics and electricity have been released for sale to the public through the Office of Technical Services: *60-11665 A Program of Automatic Differentiation for the BESM Computer*, L. M. Vega and others, Institute of Precision Mechanics and Calculating Techniques, Moscow, June 1960, 14 pages, 50¢; *60-21735 Innovations in Communications Technology*, Vestnik Svyazi, USSR, 1960, 2 pages, 50¢; *60-21715 Constant Electric Field Surfaces*, N. J. Felici, Revue Generale de l'Electricite, 1960, 66 pages, $1.75; *60-11804 On the Property of Functions Being Realized by Nonplanar Nonrepetitive Circuits*, A. V. Kuznetsov, Akidemiya Nauk SSSR, Matematicheskiy Institut, Trudy, June 1960, 15 pages, 50¢; *60-21774 Resonance Absorption of Sound in Paramagnetic Materials*, translated by S. A. Altshuler, Akademiya Nauk SSSR, Doklady, May 1960, 6 pages, 50¢; *60-21478 The Component Bridge "Wayne Kerr" Type V-512*, Vestnik Svyazi, USSR, 1960, 1 page, 50¢; *60-21171 Cumulative Probability of Recognizing a Signal on a Radar Set*, translated by R. P. Illwitzer, N. M. Sedyakin, Radioteknika, USSR, March 1960, 5 pages, 50¢; *60-21765 Some Optical Investigations of a High-Power Pulsed Gas Discharge in Hydrogen*, translated by R. P. Illwitzer, P. S. Kireyev and A. A. Yuzefovich, Moscow University Vastnik, Seriya Matematiki, Mekhaniki, Astonomii, Fiziki, Khimii, USSR, May 1960, 7 pages, 50¢. All these publications are obtainable from Publications & Public Information Division, OTS, United States Department of Commerce, Washington 25, D.C.

INTERNATIONAL LIGHTING DEVELOPMENTS—CIE PROCEEDINGS. The proceedings of the technical sessions of the Commission International de l'Eclairage (International Commission on Illumination) held in Brussels in June 1959, comprised of contributions from more than 500 delegates from 24 countries, have been organized into four volumes: *Volume A—Sources of Radiation*, 212 pages; *Volume B—Lighting Technology*, 160 pages; *Volume C—Lighting Applications*, 148 pages; *Volume D—Lighting for Transport*, 96 pages. Prices for the set of four volumes is $20. It may be ordered from T. D. Wakefield, Treasurer, U. S. National Committee, CIE, The Wakefield Company, Vermilion, Ohio.

NUCLEAR ELECTRONICS. Volumes I and II. In this IAEA (International Atomic Energy Agency) publication of the proceedings of the *Colloque international sur l'Electronique nucléaire*, held in Paris in September 1958, organized by the *Société française des Radioélectriciens*, papers are reproduced in author's language, English or French. Among subjects covered are: Scintillation Radiation Detectors, Reactor Control Measurements, Equipment for Protection of Personnel, and Prospecting. It is of interest to scientists, industrialists, equipment manufacturers, and electronics specialists. Available from National Agency for International Publications Inc., 801 Third Ave., New York 22, N.Y. for $4 per volume.

AEC PUBLICATIONS. *Fossil Fuels in the Future, TID-8209* reviews fossil-fuel resources and in order to estimate the earliest time when large amounts of nuclear power will be needed, forecasts the estimated rate at which they will be depleted in the absence of new sources of energy. Price 75¢. *Three Design Studies for Selecting a Prototype Reactor for a Nuclear Tanker, TID-8528* is a summary and evaluation report made by an evaluation group convened by the Commission's Division of Reactor Development and the Maritime Administration of the U. S. Department of Commerce to consider three nuclear-powered tanker design and engineering studies. Price $1.25. *A Compendium of Information for Use in Controlling Radiation Emergencies, TID-8206(Rev)* contains a summary of the lecture material presented during a radiological assistance training course held in February 1958, at Idaho Falls, for personnel who have responsibilities for minimizing the effects of incidents involving radioactive materials. Included is a compendium of data and information for use during emergencies, and a reference list of 184 publications on the subject of radiation and its control. Price $1. Publicaiton may be ordered from Office of Technical Services, Department of Commerce, Washington 25, D. C.

SYMPOSIUM ON NONDESTRUCTIVE TESTING IN THE MISSILE INDUSTRY. The purpose of this symposium was to establish a background of unclassified literature on a limited number of specific applications of nondestructive testing and to stimulate thinking by outlining many of the present nondestructive testing problems in the missile industry. Topics include Radiography of Large Solid-Propellant Rocket Motors; High-Energy Radiography in the 6- to 30-mev Range; An Ultrasonic Method to Detect, Count, and Measure Fluid-Contaminating Particles; etc. It is obtainable from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., for $2 per copy.

DIGITAL COMPUTERS AND NUCLEAR REACTOR CALCULATIONS. Nuclear reactors and high-speed digital computers are already recognized as going together "hand-in-glove" but since very few individuals can be expected to be experts in all the necessary technical fields needed for a reactor code, an introduction to the subject that can serve both needs is the primary objective of this volume. The author, Dr. W. C. Sangren, Chief of Mathematics and Computing at the John Jay Hopkins Laboratory for Pure and Applied Science, General Atomic Division of General Dynamics Corp., presents his material in two major sections. The first four chapters deal with an introduction to reactor problems, digital computers, programming, and numeral analysis. In the remaining chapters the considerations involved in actual reactor calculations are discussed. It is available from John Wiley & Sons, Inc., 440 Park Ave. South, New York 16, N.Y. for $8.50 each.

FERRITE STANDARD. *Recommended Specification for Transformer Cores of Ferro-Magnetic Oxides for Telecommunication 34-60.* applies to E, I, L, U, and pot cores for transformers used in telecommunication equipment and similar electronic devices with the exception of powder transformers. It establishes uniform rules for specifying those core properties which may be of importance in their most common applications and evaluates the methods for verifying these properties. Characteristics considered include maximum turn factor, total losses, temperature constant, instability and reversible turn factor. Copies may be obtained from the Ferrite Manufacturers Association, 60 E. 42nd St., New York 17, N.Y. at 50¢ per copy.

THE PHYSICAL AND THERMODYNAMIC PROPERTIES OF HELIUM. The revised edition of this reference book, originally published in 1957, summarizes currently available information on the physical and thermodynamic properties of gaseous helium. The information is presented in both tabular and diagrammatic form to facilitate its use by design and test engineers who work with pressurized helium. The reported property values cover the pressure range of —440 to 600 F, with minor exceptions where data were limited or unavailable. The publication has been compiled by Whittaker Controls, division of Telecomputing Corporation, and is available by writing to same, 915 North Citrus Ave., Los Angeles 38, Calif. Price $10.

TRANSISTOR MANUAL. This fifth edition contains four new chapters: Tunnel Diode Theory and Switching Circuits, Tunnel Diode Amplifiers, Feedback and Servo Amplifiers, and Test Circuits. The chapters on Silicon Controlled Rectifiers, Power Supplies, Transistor Specifications, and Rectifier Specifications are expanded and revised. The Transistor Specifications chapter contains a current listing of American JEDEC-registered transistor types with specifications and interchangeability information. Priced at $1 per copy, the manual is available from Semiconductor Products Department, General Electric Company, Kelley Building, Liverpool, N.Y.

ELECTRONIC MAINTAINABILITY. 29 papers prepared by industrial or military maintainability specialists and presented at the Third Conference on the Maintainability of Electronic Equipment held in December 1960 in San Antonio, Texas, have been compiled in this volume. It is available for $10 from Engineering Publishers, Box 2, Elizabeth, N.J.

SEL-REX RECTIFIERS HELP PUT GOOD LOOKS AND DEPENDABILITY INTO BUSY TALON ZIPPERS!

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New & Improved Products

(Continued from page 18A)

Glass Paper Insulation . . .

New applications are demonstrating the ability of this all-glass insulating paper to solve certain unusual electrical, thermal, and electronic problems. Called Tissuglas, the material is available in thicknesses as low as 0.00006 inch. Uniform in texture and electrical resistance, the newest and potentially widest application is for an electroluminescent lamp base. Another is in the manufacture of bonded strain gages when used as a saturating base. Still another is used as a laminate with very thin copper foil to produce the thinnest, most flexible printed circuit material now available. *American Machine & Foundry Co., 261 Madison Ave., New York 16, N.Y.*

Lightweight Integral Motor . . .

This new standard line of motors employs aluminum alloys in place of conventional cast iron construction to achieve weight reductions as high as 30%. Other advantages include improved heat transfer for cooler running, and maximum resistance to rust and corrosion. Motor frame, end-bells, bearing caps, rotor, and conduit box are all made of aluminum alloys. *Franklin Electric Company, Inc., Bluffton, Ind.*

Remote Load Indicator . . .

Using the differential transformer principle and a special inverse-ratio circuit that carries sufficient voltage for integral magnification, this remote indicating load cell system permits instantaneous readings in pounds at distances over 1,000 feet. Typical applications are in cranes, weighing hoists, ore-handling equipment, structural stresses in wind tunnels, jet engine thrusts, tensions on fishing nets or mine sweeper towing cables, and for maintaining proper tensions in catapults and aircraft carrier arresting gear. *W. C. Dillon & Co., Inc., Van Nuys, Calif.*

Low-Torque Tachometer . . .

Particularly applicable for the precise digital measurement of shaft speeds on subfractional hp motors, this instrument uses an integral light source, a 60-segment rotating interrupter, a photojunction cell, and a special transistor amplifier. The actual torque load on the measured shaft is substantially less than the "cogging" or "windage" of gears or discs associated with most no-contact magnetic or photoelectric pick-ups. Every 6 degrees of shaft rotation results in a d-c pulse of two volts. Feeding the resultant square wave into a digital counter with a 1-second time base gives an accurate reading of speed in rpm. *Servo-Tek Products Co., 1086 Goffle Rd., Hawthorne, N.J.*

Delay Relay Control . . .

The new 235 frame time delay relay rounds out a line of matching plug-in relays specifically designed for machine tools and related control applications. The unit uses a solid-state static switching timing element combined with the 219-frame relay. Standard "on" timing ranges are 1/5 to 18 seconds, and 2 to 180 seconds. Immediately recycling, the unit has repeat accuracy of $\pm 1\%$ with constant voltage. DPDT load contacts rated 10 amperes at 115 volts a-c resistive have an expected life of 20 million mechanical operations. *The Harry P. Bridge Co., 1201 Chestnut St., Philadelphia 7, Pa.*

Miniature Cryogenic System . . .

The closed cycle of this self-contained apparatus uses nitrogen to provide 1 watt of refrigeration at 80K (−316 F). The unit is unique in that it requires neither bulky gas cylinder nor a liquid storage container. Weighing only 16 pounds, the system consists of a compressor with absorber filter and a remote refrigerating element connected to the compressor by flexible lines. It is designed to run 500 hours between maintenance periods. *Air Products, P. O. Box 538, Allentown, Pa.*

Dry Type Transformers . . .

A new line of Class B ventilated dry-type single- and 3-phase transformers has been developed to deliver quiet, economical performance in plants, schools, hospitals, and public buildings. Each model is design-checked to operate at 4 to 5 db below 1960 NEMA (National Electrical Manufacturers Association) standards. Rugged yet lightweight, the transformers occupy minimum space. Terminal arrangements and liberal wiring area permit primary and secondary cable entrance from either end of the enclosure, and are designed for connecting copper or aluminum cables. *Niagara Transformer Corp., P. O. Box 23, Buffalo 25, N.Y.*

Phasing Test Set . . .

A reliable means for phase conductor identification on underground cable systems is achieved with this new test set without removing all safety grounds. The transmitter consists of a packaged steep-wave-front impulse circuit which is connected to the cable terminal and periodically sends a pulse out on one identified conductor and back on another. The detector, similar to a clamp-on ammeter, is used to identify individual conductors in a cable. *James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.*

Grid Boards Tape Kits . . .

Convenient kits of acid-resistant plastic strips and dots have been developed for laying down circuit patterns on copper-clad Fotoceram printed circuit grid boards. When the boards are dipped in a copper-etching solution, the only metal that remains is the desired circuit layout. The grid board enables designers to make prototype printed circuits without leaving their desks. Each kit contains ten 9- by 1/8-inch strips and forty 3/16-inch dots. *Corning Glass Works, Corning, N.Y.*

Portable Reference Source . . .

This portable reference source can be used to calibrate voltmeters, provide accurate power up to 10 volts, or operate as a voltmeter in the 0- to 100-volt range for alternating or direct current. Accuracy is $\pm 0.25\%$ of set voltage above 0.01 volt and $\pm 0.20\%$ of set voltage below 0.01 volt. Accommodations can be made for frequencies other than 60 cps. *Tensor Electric Development Co., Inc., 1873 Eastern Pkwy., Brooklyn 33, N.Y.*

Building Block Logic Kit . . .

The components of this kit are particularly suitable for educational purposes, serving both as aids to classroom instruction, and as versatile pieces of laboratory apparatus. Up counters, down counters, 4-bit shift registers, decimal and Gray-to-binary decoders, and 2-binary-digit adders and subtracters are among the numerous pieces of pulse apparatus. These can be quickly assembled since all logical interconnections are made on the graphic front panels by means of handy stacking banana-jack patch cords. The kit contains nine 500-kc building blocks, a mounting panel, power supply, and 100 patch cords. *Digital Equipment Corp., Maynard, Mass.*

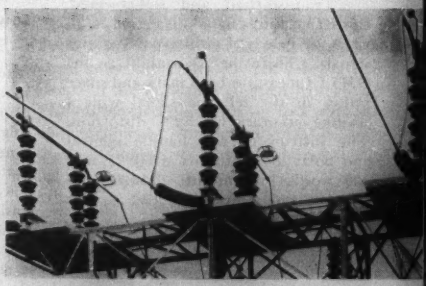
(Continued on page 44A)

3-POLE SWITCH IS OPENED by the efforts of one man. Heavy weight of ice required extra effort, but switches were fully opened and were in operative condition after each test.

TO YOUR AIR BREAK SWITCHES?

The reason for the WAG's good performance under ice is simple: engineering and construction. The relationships of all moving parts are such that ice formations are in shear or tension. Force transmitting linkages are well-protected from ice accumulation. And all moving members are rugged enough to prevent deformation when the switch is forced open or chopped into the closed position.

Southern States Type WAG will operate effectively under ice and other adverse operating conditions. For complete details, contact your Southern States representative or write us for Bulletin 59 WAG.



Baltimore Gas & Electric Company uses Southern States 230 kv, 1200 ampere WAG Switches as OCB disconnects on its Northwest substation, seen in the above photograph.

SOUTHERN STATES EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

New & Improved Products

(Continued from page 36A)

Die-Stamped Circuits . . .

Combining economy with reliability, these mass-produced circuits are made by die cutting the conductor pattern from metal foil coated on one side with a thermoresponsive adhesive, and then bonding the circuit to the insulating base material under heat and pressure. Use of long-wearing embossing dies permits production runs of approximately 4 million circuit boards without die change. Thoroughly field tested, these die stamped circuits are now being mass-produced for a wide variety of automotive, appliance, and control applications with growing acceptance in the fields of instruments, computers, television sets, toys, etc., requiring electrical or electronic circuits. *Dytronics, Inc., 115 Main St., Rochester, Mich.*

Microfilm Copier . . .

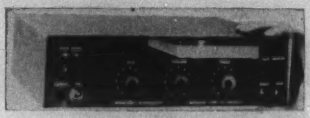
Available for lease or sale, this xerographic copier will reproduce sharp 18- by 24-inch black-on-white prints from small microfilmed engineering drawings. The machine was designed particularly for low-volume drawing users, or for those beginning to use a unitized microfilm system. The Copyflo 1824 will print on ordinary cut-sheet paper, or will provide an offset paper master ready for immediate use. *Haloid Xerox, Inc., 8-1824 Haloid St., Rochester 3, N.Y.*

Signal-Distortion Measurer . . .

Transistorized and self-powered, this set measures signal distortion in all types, or speeds of ordinary teleprinter signals. Featuring portability, the *DMS-1A* measures both mark and space pulses in the teletype signal with a reading accuracy to $\pm 2\%$ distortion. The instrument will handle neutral and polar loop currents at 60, 75, and 100 words per minute. *Atlantic Research Corp., Alexandria, Va.*

Cartridge Tape Recorder . . .

This completely automatic, extremely compact, magnetic tape player was specifically designed to eliminate all handling operations, thereby making magnetic recordings easier to play



than standard phonograph records. Cartridges containing endless loops of 3M specially lubricated tape in lengths of 300, 600, or 1,200 feet are simply inserted into the player, and the "start" button pressed. Both stereophonic and monophonic record-play facilities are available. These utilize 1, 2, 3, or 4 tracks operating at 1⅞, 3¾, 7½, and 15 inches per second. *Amplifier Corp. of America, 398 Broadway, New York 13, N.Y.*

Binary Code Generator . . .

Basically a shaft position encoder in which minutes, hours, days, and weeks are represented on coded discs, this new concept in binary time code generation may be applied to data processing, automatic controls, computing, and transmitting systems. One version of the generator is now being used in a completely automated parking lot for computing fees. When parking tickets are placed in a "time-out" slot, the device automatically determines the time the car has been garaged, computes the charges, and allows for special night or holiday rates and other time-charge variations. *The A. W. Haydon Co., Waterbury, Conn.*

Low-Cost Synchronous Motor . . .

Two years of engineering research for a constant-speed phonograph motor that offers mass production economy without sacrificing superior quality has produced this radically new synchronous motor. Combining the features of hysteresis motors with the lower cost of shaded pole motors, the basic design innovation involves permanent magnetization of both ends of an induction motor, giving the rotor a combination of synchronous and induction torque. Since the motor is permanently locked into synchronous speed, this feature makes it ideally suited for driving phonographs, tape recorders, and similar mechanisms. Other applications include transcription turntables, timers, and equipment associated with recording charts and graphs. *The Alliance Manufacturing Co., Alliance, Ohio.*

Power Tube . . .

The *WL7540*, a new low-mu triode industrial power tube, was designed for zero-drive power amplifier service in shaker table and sonar equipment. Rated for 35-kw dissipation during continuous service at audio frequencies, the tube employs a thoriated-tungsten cathode, and has an accurately aligned integral water jacket for steam-free operation under severe beaming conditions. *Westinghouse Electric Corp., Electronic Tube Div., P. O. Box 284, Elmira, N.Y.*

Hopper Heaters . . .

Ice, snow and frozen residual material can be quickly and economically removed from railway hopper cars before loading with these specially designed electric radiant heaters. Used in pairs, the heaters are placed between the rails directly under the cars. Each unit contains 16 alloy-sheath Chromalox heating elements with threaded-end, waterproof fittings and requires maximum power of 32 kw at 240 volts 3-phase. *Radcor, Inc., Bradner, Ohio.*

Vol. 80
1961

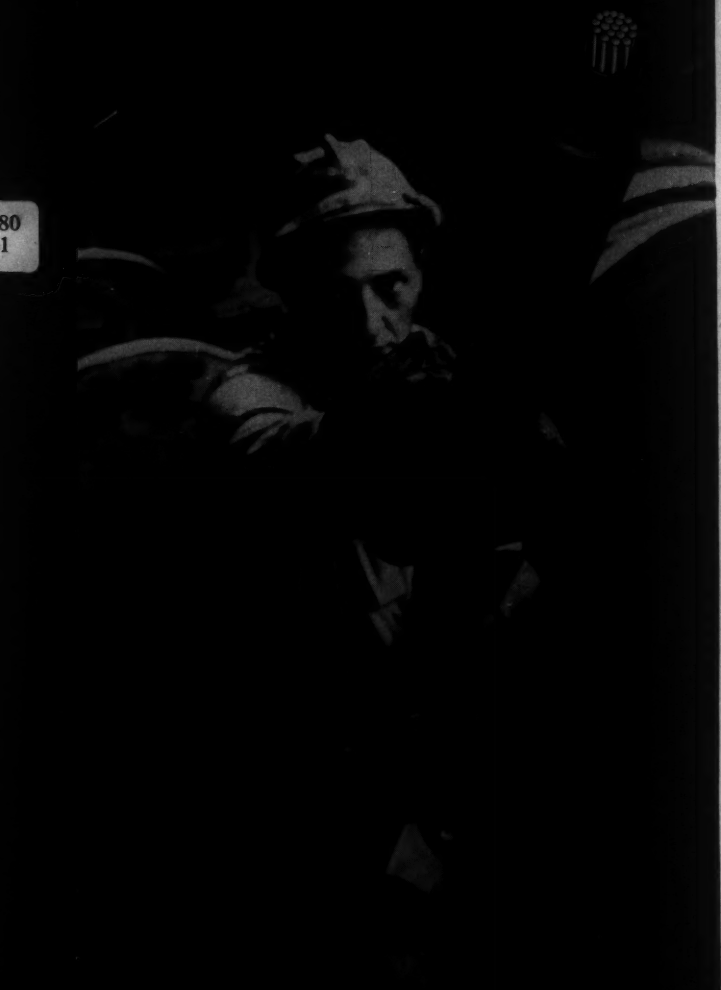
Cardiac Monitor . . .

A monitor will soon be added to the cardiac pacer now available to the medical profession. This unit will have thin flexible leads to the pacer so that in the event of a heart arrest the pacer will be triggered to give electrical stimuli at a preset rate and amplitude. Similar to the pacer, the monitor will be self-powered and fully transistorized for maximum mobility and portability. Another feature will be inclusion of a radio transmitter to broadcast a coded alarm signal in an emergency. *Westinghouse Electric Corp., Box 2278, Pittsburgh 30, Pa.*

Ultrasonic Liquid Level Control . . .

The Sonoswitch affords a safe means of controlling all types of liquids including those that are corrosive or explosive. The explosion-proof stainless steel probe actuates instantly when any liquid touches its sensitive probe surface. With a repeatability within thousandths of an inch, the device is affected by neither film nor scale. Capable of operating at pressures over 2,000 psi, the probe has no moving parts to be fouled, and can be used as an over-fill or low-level alarm for automatic pump start-up and shut-down, or for a variety of centralized solenoid valve programs. *Powertron Ultrasonics Corp., Patterson Place, Roosevelt Field, Garden City, N.Y.*

5 KV ? 15 KV ?



HIGH-VOLTAGE CABLES—IN THE LENGTH YOU NEED—NOW AVAILABLE "OFF THE SHELF"

More and more contractors are being invited to bid on projects which include high-voltage cable.

Now *you* can go after this profitable business, because Rome has made it possible for you to:

1. Get the cable you need, *when* you need it, in the *length* you need.

2. Get cable of the *quality* the job requires. (In high-voltage work, "second best" cables can eat up your profits during call-back after call-back.)

Today you can order the length of high-voltage cable you need—ten feet or ten thousand—right "off the shelf," through Rome's new stockpiling program.

And you'll get the quality your customers expect—the same Rome cables that have earned their reputation the hard way: through miles upon miles of high-voltage jobs over the years.

Popular sizes 5 and 15 kv Rozone Roprene single-conductor cables are currently being stocked at Rome in the sizes most frequently needed.

This gives you a quick answer to a wide variety of cable problems. Rozone is a versatile, long-life insulation that resists ozone and moisture. Roprene is tough neoprene jacketing that resists weather, fire, oils, chemicals, heat and aging.

Start on your next job Your next bid may be on a school, commercial building, or industrial plant which requires high-voltage cable. Be ready for this business. Your Rome distributor is the man to call for 5 and 15 kv cable. Ask him about it this week.

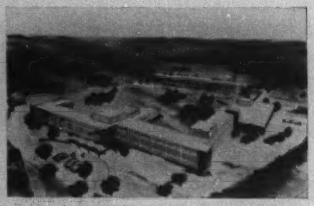
Rome Cable Division of Alcoa, Dept. 3-11, Rome, N. Y.

ROME CABLE
DIVISION OF **ALCOA**

Industrial Notes...

Sylvania Electronic
Waltham, Mass...

Sylvania Electronic Systems, a division of Sylvania Electric Products Inc., has begun construction of a new applied research laboratory facility and a new headquarters building on a 55-acre site adjacent to present division facilities in Waltham. An electronic-detonated blast signaled the formal ground-breaking for the new facilities.



Totaling approximately 107,000 square feet, the two new 2-story buildings will be located about ½ mile west of the division's 160,000-square-foot Waltham Laboratories and present 30,000-square-foot headquarters building. Completion is scheduled for August 1, 1961. Approximately 150 persons, including 90 technical personnel, will be employed initially within the new laboratory building. The headquarters facility will house about 300 engineering and administrative personnel of the division staff and Sylvania's systems engineering and management operation.

Ionics, Inc.
Cambridge, Mass...

Twelve electrically powered water desalting units for United States missile bases, worth about $950,000, have been ordered from Ionics, Incorporated. They will be used to desalt ½ million gallons per day of highly mineralized local well water to provide critical pure water supplies to Titan and Atlas underground missile bases in New Mexico, South Dakota, and Oklahoma. Requiring a minimum of attendance, a minimum of chemicals for treatment, and no steam, the Ionics units operate on the "electrodialysis" or "electric membrane" principle, which utilizes small quantities of electric energy to remove the excess dissolved salts and minerals from water supplies. The low mineral fresh water to be produced will be used for personnel needs and cooling of intricate mechanical equipment at the sites.

TRW Computers Co.
Beverly Hills, Calif...

The first large steam power plant outside the United States to employ integrated automation will be controlled by an *RW-300* digital control computer system. Electricite de France has bought two computers for automatic control of a high-power steam generating plant to be built at Saint Ouen, France. More than 600 process variables will be automatically recorded and monitored by the *RW-300* computers for this extremely complex control system. The computers will also calculate and record theoretical and actual performance values, and control the plant operation to give the desired power output at a minimum cost. The *RW-300* is a transistorized digital computer with built-in analog-to-digital conversion equipment, a magnetic drum memory, modular construction for ease of maintenance, and other advanced features.

ASM
Metals Park, Ohio...

An operational electronic literature searching service, utilizing a commercial general-purpose computer, has been developed by American Society for Metals (ASM). First offered to subscribers in January 1960, the searching service had been operated on an experimental searching selector designed and hand-built at the Western Reserve University (WRU) Center for Documentation and Communication Research, Cleveland, Ohio. In October 1960, all searching operations were transferred to commercial equipment utilizing a General Electric high-speed electronic computer. This equipment, though not specifically designed for information searching, has been readily programmed to handle the electronic requirements of the ASM-WRU data-processing system. More than 65 companies and individuals are receiving digests of the world's metallurgical literature in the particular area of scientific and technical information with which they are concerned. Use of General Electric facilities will reportedly enable ASM to service immediately and efficiently all requests for literature searches that are received. Subscriptions can now be taken to cover current literature, in which digests are delivered at bi-weekly intervals, or to make bibliographic searches of important metallurgical publications dating back to early 1958.

General Dynamics
San Diego, Calif...

The Board of Governors of the International Atomic Energy Agency (IAEA) has approved the transfer of a United States research reactor and the fuel for the reactor through the International Agency to Finland. The transfer will be made under a tripartite agreement between the Agency, Finland, and the United States. The reactor is a General Dynamics TRIGA Mark II planned for construction at the Institute of Technology near Helsinki. This will be the first transfer of special nuclear material by the IAEA. The TRIGA reactor, which is expected to be in operation in 1961, will use approximately 13,000 grams of fuel enriched up to 20% in uranium-235, and about 4 grams of highly enriched uranium. The value of the fuel will be approximately $42,000. The reactor will be located at the Institute of Technology at Otaniemi, a suburb of Helsinki, and will be used for training and research.

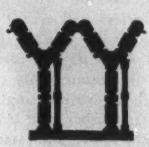
Leach Corp.
Compton, Calif...

Tape recorders developed for airborne uses by Leach Corp. are being used increasingly to supplement and possibly replace telemetry tests on the sled runs. Use of the tape recorder channels for test data relieves the telemetry bands which are becoming enormously crowded under increased United States space program demands. Proposed change-over of telemetry frequencies to a 2,000 mc band would result in huge outlays for telemetry receivers and transmitters. The

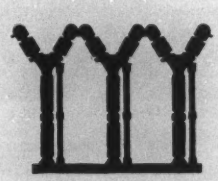
same data can be obtained from magnetic tapes after the tests. Tape recorder tests also afford perfect insurance against eavesdroppers, against which telemetry transmission can offer no protection.

(Continued on page 48A)

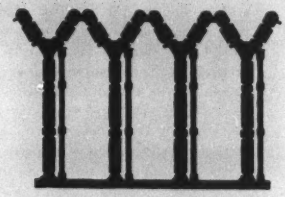
▲ 72.5 kV – 3000 MVA sym



▲ 170 kV – 7000 MVA sym



▲ 245 kV – 10000 MVA sym

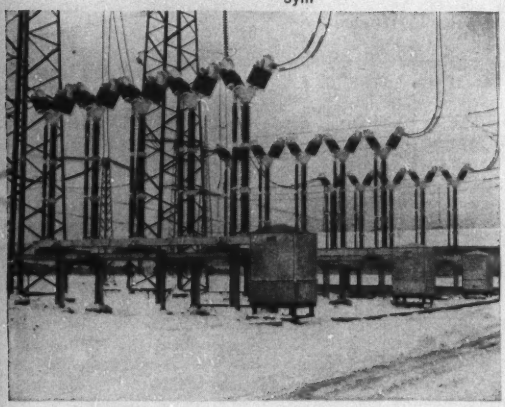


▲ 345 kV – 14500 MVA sym

▼ 420 kV – 17500 MVA sym

Field tests with 420 kV Minimum Oil Breaker

less weight
less maintenance
safer insulation
higher performance



Minimum Oil Breaker type HPF 516 at Kilforsen, Sweden 6712

In 1952 the Sprecher & Schuh Minimum Oil Breaker was the first circuit breaker using oil for arc extinction to be tested and put in service on a 420 kV system.

Based on 8 years of field experience and research S & S is now offering and delivering a new concept of improved Minimum Oil Breaker, the V-Breaker.

October 1960 the V-Breaker has proved the first circuit breaker in service on extra high voltage systems using oil for arc extinction to clear unloaded lines restrike free. The three phase field tests on 300 miles of 420 kV lines have been successfully carried up to 540 kV_{rms}

Sprecher & Schuh Ltd. Aarau - Switzerland

High-Voltage Department specialised in Circuit Breakers, Measuring Transformers, Switches and Lightning Arresters

S&S

AiResearch Minifan* is an extremely high performance 400-cycle AC motor-driven fan used for cooling airborne or ground electronic and electrical equipment. Model shown has a flow capacity of 53.5 cfm at a pressure rise of 3.44 H_2O, and requires only 69 watts.

Minifan operates up to 125°C. ambient. Its size and weight make it ideal for spot cooling, cold plates or as a cooling package component. The fan can also be repaired, greatly increasing its service life.

Range of Specifications

- **Volume flow: 21.5 to 53.5 cfm**
- **Pressure rise: .6 to 3.44 H_2O**
- **Speed: 10,500 to 22,500 rpm**
- **Single, two or three phase power**
- **Power: 16 to 69 watts**
- **Standard or high slip motors**
- **Weight: .36 to .48 lb.**

A world leader in the design and manufacture of heat exchangers, fans and controls, AiResearch can assume complete cooling system responsibility. Your inquiries are invited.

*Minifan is an AiResearch trademark.

THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

Industrial Notes

(Continued from page 46A)

Goodrich-Gulf Cleveland, Ohio . . .

Processability of a new type of high-density polyethylene, developed by Goodrich-Gulf Chemicals, Inc., is rated equivalent to that of low-density polyethylene for such applications as

wire and cable covering. Tests in the company's research laboratories show improved stress cracking and temperature embrittlement resistance, combined with the processing ease feature. Goodrich-Gulf will produce its "Ameripol Polyethylene" in a new plant now being constructed at Port Neches, Texas.

Giannini Controls Duarte, Calif. . .

Giannini Controls Corporation has been awarded a contract by Goddard Space Flight Center of the National Aeronautics and Space Administration. The contract calls for continuing research on an accelerator which may eventually be capable of reproducing orbital re-entry conditions in the laboratory. For the past 2 years, Giannini Controls has been engaged in company-initiated studies to establish the physical requirements of spaceborne instruments operating in environments created by vehicles traveling in excess of 20,000 mph. The accelerator is called the Electromolecular Instrument Simulator.

Hewlett-Packard Palo Alto, Calif. . .

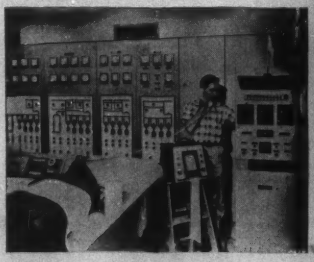
Hewlett-Packard Company has announced the formation of a new division for the development and manufacture of precision components used in electronic instrumentation. The new Precision Components Division will have its headquarters at the company's main plant in Stanford Industrial Park, Palo Alto.

Datex Corporation Monrovia, Calif. . .

Engineers at Datex Corporation are designing two radiosonde data converters for the Meteorological Division of the U.S. Army Research and Development Laboratory, Camp Evans, N.J. Designed to operate with a Rawin set, the converters will accept weather balloon tracking data in analog form and convert it to digital form. Each converter will numerically indicate azimuth angle, elevation angle, Baroswitch contact number, and elapsed radiosonde flight time. The system will record these parameters on punched paper tape in "8-level," "Fieldata" code. Special packaging is being developed for the systems.

Brush Instruments Cleveland, Ohio . . .

Direct writing recorders made by Brush Instruments, a division of Clevite Corp., are helping to maintain coding systems for controlling the flow of crude oil from West Texas to Houston. Code systems for controlling, selecting, and measuring storage tank levels at unattended pumping stations for moving crude oil from West Texas to Houston are checked out and maintained continuously to insure proper operation at all times. Groups of



pulsed signals, which are employed to operate valves, switches, and other components at the substations, are transmitted along telephone lines. Control system signals are monitored during checkout and maintenance by recording pulses on both the send and receive ends of the code system, and comparing results. Control signals, transmitted at a rate of 15 pulses per second, are recorded on 2-channel direct writing Brush Instruments Mark II recorders. The recorders are used not only in maintenance, but to set up new systems and to keep permanent records for future reference.

(Continued on page 50A)

NIAGARA

TRANSFORMERS

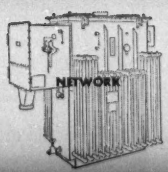
"That Niagara was out there when I started. It's been delivering power since it arrived. Never caused us a moment's trouble."

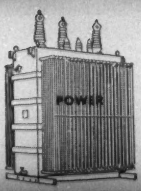
Users confirm it: Niagara Transformers are built to last a long, long time. At every stage in their manufacture, quality is strictly controlled. Everything — raw materials to completed transformers — is thoroughly tested at the Niagara plant. Specialized skills and experience assure bonus construction with liberal overload capacity.

Niagara Transformers are designed and produced for practically every service thru 10,000 kva, 69,000 volts. Write for Bulletin 139. Niagara Transformer Corp., P.O. Box 23, Buffalo 25, N. Y. Representatives in principal cities.

"After all these years, the breaker's never been opened."

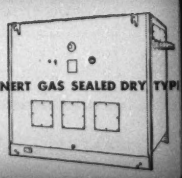
POLE TYPE


NETWORK


POWER

VENTILATED DRY TYPE

UNIT SUBSTATION


INERT GAS SEALED DRY TYPE

Industrial Notes

(Continued from page 48A)

EEI & NEMA
New York, N.Y. . .

The Industrial Electrification Council, operated since 1951 by the electrical utilities and several individual electrical manufacturers, will be co-sponsored by the Edison Electric Institute (EEI) and the National Electrical Manufacturers Association (NEMA) effective January 1, 1961. The Council was organized to conduct educational-promotional activities in the industrial market. Initially, it was concerned primarily with promoting the uses of electric heat in industrial processes, and now includes factory electric distribution systems. The Council's first project under its newly expanded activity will be the development and release of a course on plant distribution of electricity. Other projects will be developed as the enlarged and re-organized Council begins to function. Headquarters of the Council will remain in offices of the EEI, 750 Third Ave., New York, N. Y.

Beckman & Whitley
San Carlos, Calif. . .

A line of time-resolved spectrographs is presently undergoing advanced prototype testing in the Instrument Division at Beckman & Whitley, Inc. The instruments are expected to be useful primarily in the measurement and analysis of high-speed radiated transients, in work on the composition of molecular species, or in the investigation of concentration temperatures. These instruments will permit temperature measurements in the 2,000 to 20,000 K region, of events resolved in time up to 3×10^{-8} seconds, and with wavelength distribution through the 2,000 to 9,000 Angstrom range. Photographic recordings can be made of events in these classes by coupling one of the company's sweeping-image cameras to one of the spectrograph instruments. Recorded film densities, when related to a calibration standard, provide temperature measurements accurate within ± 5 or $\pm 10\%$ depending on the range of temperatures.

Ebasco Services
New York, N.Y. . .

The Atomic Energy Commission has selected as a basis for contract negotiation a proposal of Ebasco Services, Inc., for performance of complete architect-engineering services in connection with an advanced test reactor planned for the Commission's National Reactor Testing Station near Idaho Falls, Idaho. The proposed reactor project, in addition to certain support facilities, comprises a nuclear reactor, including fuel elements and nuclear core, capable of operating at a power level of approximately 250,000 kw of heat. A test reactor, through the use of nuclear radiations, tests the performance of reactor components and materials in an environment comparable to conditions in reactors for which the components and materials are intended. The reactor will be designed to accommodate experimental loops and associated out-of-pile support facilities. The contract also requires the furnishing of hazards evaluation reports. The Congress has authorized $24 million for the project. Construction of the reactor is scheduled to start by March 1961 with completion by March 1964.

Allis-Chalmers
Milwaukee, Wis. . .

An "engineering demonstrator" on wheels recently began a nation-wide tour of utilities and industrial installations. The mobile POWER/LINER, an

Allis-Chalmers Mfg. Co. project, brings to operating personnel in all major cities the latest in distribution, regulation, and protection equipment. Visitors will be able to examine, handle, and operate the many new products being demonstrated.

Lockheed
Sunnyvale, Calif. . .

Construction on a proposed $4 million expansion of Lockheed Missiles and Space Division to occupy a 172,800-square-foot engineering and laboratory building will begin early this month. The expansion of physical facilities is expected to be accompanied by a rise in employment. The new building is scheduled to be ready for occupancy by June.

Raytheon Co.
Waltham, Mass. . .

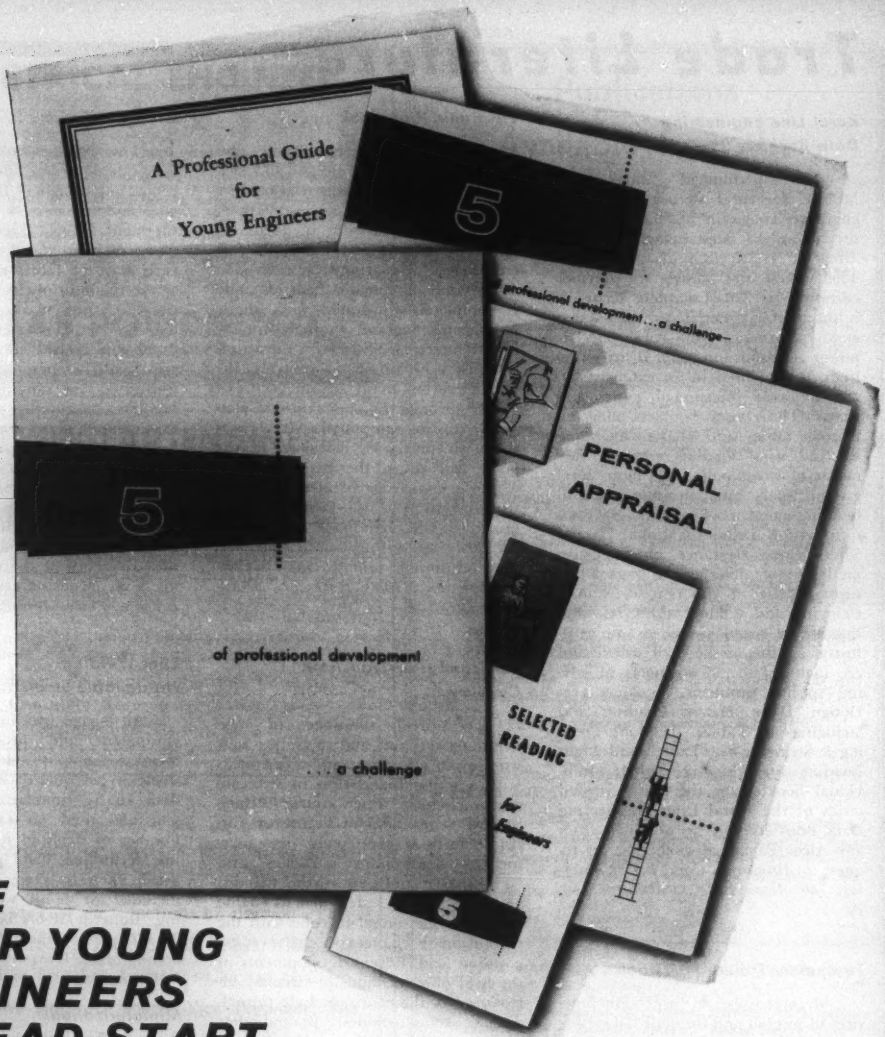
Five ferryboats in Seattle, Wash., have been outfitted with "compact" unit radars produced by Raytheon Company. The double-ended ferries each have two radars, one for each wheelhouse. All five ferries are part of a state-owned fleet of 23, carrying automobiles, passengers, and freight, and averaging 250 feet in length. The Raytheon model *1700* "compact" radar is a 2-unit system consisting of a Fiberglas-encased antenna mounted aloft and an indicator installed in the wheelhouse. The indicator has a 7-inch scope on which electronic pictures of land, other vessels, and buoys can be seen from 25 yards out to 12 miles. Price of the nine units totaled $19,755.

ITT
New York, N.Y. . .

STRAD (Signal Transmission, Reception, and Distribution), an electronic switching system that internally routes telegraph messages to their various destinations at the rate of 83,000 words a minute, is a new development of International Telephone and Telegraph Corporation's British affiliate, Standard Telephones and Cables Ltd., London. The equipment receives telegraph messages from up to 108 incoming circuits, temporarily stores them on a magnetic drum, sorts all messages according to destination, and then retransmits them in order of priority and time of arrival to appropriate circuits. Each cubicle into which the equipment is divided contains several units, each consisting of a number of subunits or cards. The system is fully alarmed so that any faults which occur are automatically localized, and parallel operation of main or duplicate common equipment is begun to assure continuity of service.

Zenith Radio Corp.
Chicago, Ill. . .

Ground has been broken for a new manufacturing plant to be built in Paris, Ill. by Central Electronics, Inc., wholly owned subsidiary of Zenith. The new plant, a 1-story structure of masonry and glass, will be built on a 30-acre tract of land, and will house facilities for production of radio receivers and the manufacture of electronic components. The plant's first unit will provide 100,000 square feet of floor space. Completion date for the new structure is June 1, 1961.



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Trade Literature . . .

Rural Line Engineering Data Booklets . . .

A multivolumed "Book-of-the-Month" for rural electric power line engineers comes in a 4-booklet series presenting the latest data for a wider range of ACSR, from Awg 6 to 4/0. The largest size shown in previous editions was 1/0. Complete technical information, essential to the design and construction of rural electric power transmission and distribution lines, is presented in an extensive array of easily interpreted tables and charts. The revised booklets offer numerous tables and charts, including ice and wind loading, resisting moments of wood poles, maximum level ground span, guy requirements, and bending moments of wood poles. Other information includes National Electric Safety Code clearance requirements, methods for determining sags when supports are at different elevations, stringing and staking tables. In addition to the tabular data, examples illustrating the methods of calculation are included to aid engineers in solving specific problems. Booklets are: Design Data; Heavy Loading and Stringing-Sag Tables; Medium Loading & Stringing-Sag Tables, and Light Loading Stringing-Sag Tables. Individual booklets or the entire revised series of the Rural Line Engineering Data Booklets may be obtained from any Alcoa/Rome sales office or on request to *Aluminum Company of America, 760 Alcoa Bldg., Pittsburgh, 19, Pa.*

Equipment Failure Prediction . . .

Maintenance and inspection practices to foretell and forestall failure for many different types of electrical industrial equipment are described in this recently compiled manual. Amply illustrated by graphs, tables, and pictures, the 52 pages of data highlight methods and instruments for voltage breakdown tests, and for measurement of insulation leakage at high voltage. Procedures for predicting life of motor and generator insulation, and testing for breakdown of cable installations, rebuilt motors, and generators are described. Precise performance data and case histories of actual applications in industry are included. Manual D-62, entitled, "Methods and Instruments for Maintenance of Generators, Motors, and Power Equipment," may be secured by writing *Associated Research, Inc., at 3777 W. Belmont Ave., Chicago 18, Ill.*

Electronic Handbook . . .

"The Electronic Handbook" covers the application of electric and electronic controls in commercial and industrial air-conditioning installations. The handbook explains in detail the theory of electric and electronic control, makes comparisons between electronic and pneumatic controls, and is completely illustrated with photographs and diagrams. Prepared for use by architects, engineers, contractors, and users of automatic controls, the booklet reveals many advantages to be gained through the application of electronic control equipment. A review of the basic principles described in the book will equip the reader with a working knowledge of electronic control operation. All information contained in the handbook is directed primarily to heating, ventilating, and air-conditioning applications. *Barber-Colman Co., 1300 Rock St., Rockford, Ill.*

Semiconductor-Transistor Circuitry . . .

To provide thousands of engineers, technicians, and specialists now working in electronics and allied fields with a sound foundation in semiconductor circuitry, a new course "Principles of Semiconductor-Transistor Circuits" features completely new texts such as "Semiconductor Diodes" and "Transistors and Transistor Circuits and Applications," designed to enable electronics personnel to cope with the revolutionary changes in this ever-expanding field. Recent developments in the field of semiconductor circuitry introduced in the course include tunnel-diodes; zener diodes; photodiodes; phototransistors; drift transistors; and p-n-i-p, n-p-i-n, p-n-p-n, n-p-n-p, surface-barrier, and field-effect transistors. Instruction on semiconductor-transistor circuitry emphasizes basic principles and methods of transistor circuit analysis. Circuits are analyzed both graphically and from the equivalent circuit approach. Covered in detail are a variety of circuits and applications including small-signal amplifiers; power amplifiers; oscillators; detectors; switching circuits; power supplies for transistorized equipment; and practical transistor circuits such as transistor intercoms, hi-fi preamplifiers, and superheterodyne receivers. Complete details and the sequence of study available from *International Correspondence Schools, Scranton 15, Pa.*

Urethane Foam . . .

This 24-page brochure, prepared as a dual-purpose pictorial progress report and designer's fact file on industrial and commercial applications for urethane foams, traces the development of urethane foams from their early days of fabrication a few years ago to the multiplicity of end-use functions that now marks the fast-expanding horizons for these materials. A number of special industrial categories are treated separately in the well-illustrated text, ranging from the more familiar cushioning applications to exotic experiments geared to the space age. Property and performance data relating to such fields of use as insulation, structural panels, missile components, industrial packaging, acoustical artifacts, void-filling, and potting compounds, are well-defined for practical reference at the material specifying level. *Mobay Chemical Co., Penn Lincoln Pkwy. W., Pittsburgh 5, Pa.*

Spot Welding Hardenable Steels . . .

An 8-page brochure describes the equipment and procedures recommended for spot welding hardenable steels. Weld quality is classified, and data charts summarize the welding schedules used on various steels. A number of steels to which spot welding technique can be adapted are listed. Step by step instructions are included for set-up, welding, and testing. Bulletin SP-6A is available from *The Taylor Winfield Corp., 1048 Mahoning Ave., Warren, Ohio.*

Miniaturization Awards Brochure . . .

The 1960 awards brochure of the Miniaturization Awards Committee is now available. This annual interindustry competition, now in its fourth year, honors the individual, company, or organization who, in the opinion of the judges, has made the year's most significant contribution to furthering the concept of miniaturization. The illustrated brochure contains the history and purposes of the award, and criteria used in judging, as well as information on how to enter the competition. Winners of previous years are described. Write to *H. D. Gilbert, Chairman, Miniature Awards Committee, Box #604, Keene, N.H.*

(Continued on page 56A)

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Publications Available from the AIEE

The following publications are sponsored jointly by the American Institute of Electrical Engineers and the other societies mentioned below.

1. **PROCEEDINGS OF THE EASTERN JOINT COMPUTER CONFERENCE** (Computers in Business and Industrial Systems), Nov. 7-9, 1955, Boston, Mass.

   Sponsors: The Association for Computing Machinery, AIEE, The Institute of Radio Engineers.

   100 pages, 15 papers and discussions. Price: $3.00.

2. **PROCEEDINGS OF THE EASTERN JOINT COMPUTER CONFERENCE** (Computers with Deadlines to Meet), Dec. 9-13, 1957, Washington, D.C.

   Sponsors: The Institute of Radio Engineers, The Association for Computing Machinery, AIEE

   259 pages, 48 papers and discussions. Price: $3.00.

3. **PROCEEDINGS OF THE WESTERN JOINT COMPUTER CONFERENCE,** Feb. 26-28, 1957, Los Angeles, Calif.

   Sponsors: The Institute of Radio Engineers, AIEE, The Association for Computing Machinery

   240 pages, 37 papers and discussions. Price: $4.00.

4. **PROCEEDINGS 1957 ELECTRONICS COMPONENTS SYMPOSIUM,** May 1-3, 1957, Chicago, Ill.

   Sponsors: AIEE, The Institute of Radio Engineers, Radio-Electronics-Television Manufacturers Association, West Coast Electronic Manufacturers Association; also Agencies of the U. S. Department of Defense, and the National Bureau of Standards

   282 pages, 43 papers. Price: $5.00.

5. **1958 NATIONAL TELEMETERING CONFERENCE,** June 2-4, 1958, Baltimore, Md

   Sponsors: Institute of Aeronautical Sciences, AIEE, Instrument Society of America, American Rocket Society

   317 pages, 63 papers and abstracts. Price: $4.00.

6. **NONLINEAR MAGNETICS & MAGNETIC AMPLIFIERS PROCEEDINGS,** Aug. 6-8, 1958, Los Angeles, Calif.

   Sponsors: AIEE, The Institute of Radio Engineers, The Instrument Society of America

   482 pages, 30 papers. Price: $7.00.

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ENGINEER WITH EXPERIENCE in electronic circuits, measuring instruments, urgently needed. Good working conditions. Excellent chance for advancement. Ad-Yu Electronics Lab., Inc., 249 Terhune Avenue, Passaic, N. J., GRegory 2-5622.

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ELECTRICAL ENGINEER. We are a medium-sized, growing paper manufacturer in northeastern Wisconsin and we have an opening for an electrical engineer. Candidates should have two or more years of experience in medium and low voltage generation and distribution and motor control including speed regulating systems. We offer a good starting salary with plenty of opportunity for advancement and excellent fringe benefits including a profit-sharing retirement plan. Write Box 114. All replies will be held in strict confidence and personal interviews will be arranged in the near future.

Trade Literature

(Continued from page 54A)

Semiconductor Germanium . . .

Technical Bulletin HP-102 describes the various grades of semiconductor germanium available, including germanium-dioxide, first reduction germanium metal, and intrinsic polycrystalline germanium. The data sheet offers specifications including ingot size, packaging, resistivity, etc. The bulletin, which also describes the company's refining service for reclamation of germanium from scrap such as crystal ends, broken slices, saw dust, acid etchants, ores, and residues, lists availability of semiconductor grade germanium in ingots from 50 grams per inch to 120 grams per inch in lengths to 20 inches maximum. *High Purity Metals, Inc., 340 Hudson St., Hackensack, N. J.*

Replacement Transistors . . .

This complete line of replacement transistors was developed in response to the need of the American market. Now an "Interchangeability Chart" lists all Japanese-made radio transistors and the company's own American-made replacements. Over 100 different transistor types used in virtually every Japanese-made transistor radio, and their American counterparts are included. For the chart and separate price lists, write to *Electronic Transistors Corp., 9226 Hudson Blvd., North Bergen, N.J.*

Arc Welding Film . . .

A 16mm film in full color and sound on shielded arc-welding procedures is titled "Fundamentals of Manual Shielded Arc-Welding Techniques." Adapted from General Electric Company's previously released 6-film series, "Inside Arc-Welding," the film has been edited to two reels and is 45 minutes in length. Part one covers flat and horizontal arc-welding techniques and is 22 minutes in duration. The 23-minute second reel studies vertical and overhead arc-welding procedures. Close-ups of the welding arc in actual operation are featured, and the four basic principles of arc-welding—current setting, speed of travel, length of arc, and angle of electrode—are graphically explained. In addition, good and bad examples of arc-welding are examined. Film prints may be obtained on loan and without charge by contacting the local representatives of *Air Reduction Sales Company, a division of Air Reduction Company, Inc., 50 E. 42nd St., New York 17, N.Y.*

Product Guide . . .

The Product Guide—a 20-page, illustrated booklet for 3-ring binders, gives installation and application data on a complete line of fuse panels, service entrance equipment, general-purpose switches, general-purpose toggle switches, safety switches, industrial switches, and double-throw switches. Cabinet dimensions of all units are also included. A special engineering data section gives allowable current-carrying capacities of insulated copper conductors in amperes, the number of conductors in conduit or tubing, and load and circuit information for residential electric systems. *The American Electric Switch Div., The Clark Controller Co., 1146 E. 252nd St., Cleveland 10, Ohio*

Calcium Data Sheet . . .

A 2-page data sheet describes a continuous, automatic method for determining the presence of calcium down to parts per million at a rate of 20 analyses per hour. The analytical procedure is detailed, and a flow diagram of the analytical system, and actual chart recordings derived therefrom, are included. *Technicon Controls, Inc., Chauncey, N.Y.*

Nuclear Education . . .

A 76-page compendium of nuclear education programs in the United States lists 175 schools offering instruction in nuclear fields. The main section of the brochure details the degrees, courses, and facilities at each university, and notes the availability of fellowships and assistantships. A table summarizes this information for those institutions offering a formal degree in nuclear science, or offering nuclear options as part of a conventional degree. Additional tables list institutions with plasma and thermonuclear research facilities, particle accelerators, and gamma radiation facilities. Existing or planned university reactor installations are indicated according to type. More than 300 colleges and universities were polled. The brochure also includes information pertaining to special fellowships in nuclear science and engineering offered by the U.S. Atomic Energy Commission. Request "Education Programs and Facilities" from *University Relations Div., Oak Ridge Institute of Nuclear Studies, P. O. Box 317, Oak Ridge, Tenn.*

(Continued on page 60A)

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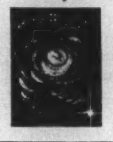

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SOVIET COMPUTER TECHNOLOGY—1959

If you are interested in this subject, you should read the report of the United States delegation to Russia in the technical specialty of computers, May 1959. 120pps., presented topically. Profusely illustrated, with a bibliography of relevant Soviet documents.

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UPTON, LONG ISLAND, N. Y.

Trade Literature

(Continued from page 56A)

"Display Devices" . . .

"Display Devices" compares electromechanical characteristics of industrial cathode ray tubes and recording storage tubes. The brochure details 65 industrial cathode ray tube types, and 7 single and dual-gun recording storage tube types, now available. In a complete and simplified chart, types offered by all manufacturers are listed in numerical order, indicating the physical and electrical characteristics, typical application, and operating conditions of each. *William Weed, Raytheon Co., Industrial Components Div., 55 Chapel St., Newton 85, Mass.*

Circular Slide Rule . . .

A handy Circular Slide Rule for simple calculations is offered free of charge to engineers and other plant and office executives. Complete easy-to-follow instructions will be included with each slide rule. The manufacturer stresses simplicity and accuracy. Write on your business letterhead to *General Industrial Co., 1788J Montrose Ave., Chicago 13, Ill.*

Membrane Filter Bibliography . . .

A bibliography of the uses of the membrane filter in chemistry contains 141 references to unique uses of the membrane filter. Among the techniques and uses referred to in this bulletin are detection of radioactivity in water, filtration of colloids, particle-free solutions for crystal growth, concentration of high molecular weight proteins, and application of membrane filters in analytical chemistry. *Gelman Instrument Co., 106 N. Main St., Chelsea, Mich.*

Plotting Data . . .

A 5-page technical data sheet describes transistorized *xy* plotting boards, both single and dual-arm, with electroluminescent panels for backlighting. Detailed features and specifications are given for the 30- by 30-inch units, designed for plotting data from digital and analog computers and for plotting tracking data from missile-range instrumentation systems. For form 80-392, write to *Computer Systems, Inc., Culver Rd., Monmouth Junction, N.J.*

Sound Barrier Effectiveness . . .

A 12-page engineering report explains in detail how to calculate the effectiveness of a partition or sound barrier. The booklet, based on research done for the publisher by the firm of Bolt, Beranek and Newman, acoustical consultants, treats building walls, movable office partitions, machinery enclosures, and other sound-containing structures. In addition to showing the sound transmission characteristics of a number of conventional wall constructions, the report includes calculation methods applicable to most simple partitions. One method determines sound transmission for a wall of several common materials in any thickness. A second method permits calculation of the effect of adding sheet lead to an existing partition. "Noise criterion" charts are also included so that reasonable sound level targets can be set. For your copy of "Improved Sound Barriers Containing Lead," write to *Lead Industries Association, 292 Madison Ave., New York 17, N.Y.*

Instrumentation Chain . . .

A 5-page report describes a typical instrumentation chain for missile-range instrumentation, including vehicle tracking, plotting of tracking data, and control of target acquisition equipment. The report establishes the operational situation for a hypothetical missile range, lists the instrumentation required, diagrams the complete equipment interconnection, describes the installation and operation of computation equipment, and indicates problems in instrumentation and their solution. Request form 80-350-TC-3 from *Computer Systems, Inc., Culver Rd., Monmouth Junction, N.J.*

"Dust Topics" . . .

A 44-page publication, "Dust Topics," describes new equipment for dust surveys, air pollution analysis, radiation protection, and special submicron filtration apparatus. Apparatus and techniques of measuring and filtering submicron contamination are discussed, and devices are illustrated which allow determination of airborne dirt in ultra-clean areas. Special filters are described which can remove particles of less than 0.5 micron from missile hydraulic and fuel lines. Complete specifications, operating characteristics, and prices are given for each item. More than 100 different instruments are described. *Gelman Instrument Co., 106 N. Main St., Chelsea, Mich.*

Space and Sciences Weekly Contents . . .

The inaugural issue of a comprehensive weekly listing of the 110,000 articles reported in the space and physical sciences each year will appear this month. The service is designed to help individual scientists keep abreast of the avalanche of research reports emanating from thousands of research laboratories throughout the world. "Current Contents of Space and Physical Sciences" enables scientists to locate quickly essential reading in such fields as missiles and rockets, computers, mathematics, physics, chemistry, instrumentation, atomic energy, and all other subject areas in the space and physical sciences. The contents of a selected list of more than 425 primary journals will be reported, with all foreign-language titles translated into English. More than half the articles will be reported in advance of original publication, a service made possible through receipt of advance proofs from co-operating scientific societies and publishers throughout the world. *Institute for Scientific Information, 1122 Spring Garden St., Philadelphia 23, Pa.*

"Stand-Off Fasteners" . . .

An illustrated 20-page booklet contains information on all types of stand-off fasteners, used to support tubing, wire bundles, conduit, equipment, and instruments. "What You Should Know About Stand-Off Fasteners" covers such subjects as: advantages and disadvantages of various designs and materials, installation costs and how to reduce them, high cost of unnecessary re-work, when to use special types, how to compare costs realistically, how to select fasteners, weight saving, causes of failure, and installation procedures. *Western Sky Industries, 21301 Cloud Way, Hayward, Calif.*

Adhesives Bulletin . . .

A thorough discussion of the selection of adhesives, bonding techniques, testing methods, and a glossary of adhesive terms, are contained in engineering bulletin no. 701. The bulletin includes a discussion of the characteristics of principal adhesives. A useful table lists the most common causes of bond failure, and recommends remedies for such failures. A complete glossary of adhesive terms, photos, and sketches is included. Write on your company letterhead to *J. W. Brush, Jr., Adhesives Dept., Raybestos-Manhattan, Inc., Bridgeport, Conn.*